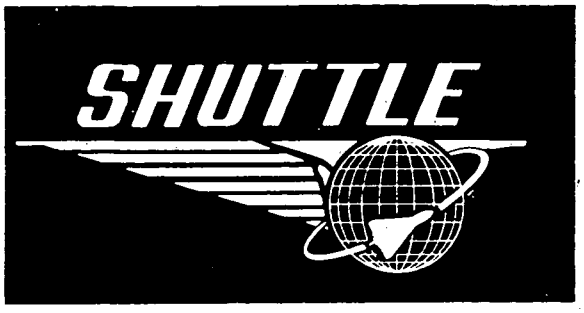

LMSC-A991396
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FINAL REPORT

SHUTTLE CRYOGENICS SUPPLY SYSTEM OPTIMIZATION STUDY

VOLUME V B-4

PROGRAMMERS MANUAL FOR SPACE SHUTTLE ORBIT INJECTION ANALYSIS (SOPSA)

CONTRACT NAS9-11330

Prepared for Manned Spacecraft Center
by
Manned Space Programs, Space Systems Division

LOCKHEED MISSILES & SPACE COMPANY, INC.
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION

FINAL REPORT
SHUTTLE CRYOGENIC SUPPLY SYSTEM
OPTIMIZATION STUDY

VOLUME VB-4

PROGRAMMERS MANUAL FOR SPACE SHUTTLE ORBIT INJECTION SYSTEM ANALYSIS (SOPSA)

FOREWORD

This Final Report provides the results obtained in the Shuttle Cryogenics Supply System Optimization Study, NAS 9-11330, performed by Lockheed Missiles & Space Company (LMSC) under contract to the National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas. The study was under the technical direction of Mr. T. L. Davies, Cryogenics Section of the Power Generation Branch, Propulsion and Power Division. Technical effort producing these results was performed in the period from October 1970 to June 1973.

The Final Report is published in eleven volumes*:

Volume I	Executive Summary
Volumes II, III, and IV	Technical Report
Volumes VA-1 and VA-2	Math Model – Users Manual
Volumes VB-1, VB-2, VB-3, and VB-4	Math Model – Programmers Manual
Volume VI	Appendixes

The LMSC Staff participants are as follows:

Study Manager	L. L. Morgan
Subsystem Evaluations	C. J. Rudey
	D. P. Burkholder
	C. F. Merlet
	W. H. Brewington
Integrated Systems	H. L. Jensen
Component Analyses	B. R. Bullard
	F. L. Bishop

*The Table of Contents for all volumes appears in Volume I only. Section 12 in Volume III contains the List of References for volumes I through IV.

Thermodynamics	G. E. Heuer
	R. M. Vernon
	J. Gries
	D. R. Elgin
Thermal Protection	G. E. Heuer
	R. Cima
Fluid Dynamics	D. P. Burkholder
	R. Cima
Propellant Acquisition	M. P. Hollister
	R. K. Grove
Design	R. A. Michael
Structural Analysis	M. L. Vaughn
	C. C. Richie
Instrumentation	R. R. Gaura
Reusability/Reliability	R. F. Hausman
Failure Modes and Effect Analyses	D. C. Saunders
Requirements and Criteria	C. F. Merlet
Safety and Mission Completion	C. F. Merlet
Math Model	R. F. Hausman
	J. McKay

Cryogenic Cooling Subtask

Subsystem Evaluation	H. L. Jensen
Component Analysis	G. Heuer
	AiResearch
Thermodynamics	R. Cima
Thermal Protection	G. E. Heuer

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INTRODUCTION

SOPSA (Space Shuttle Orbit Injection Propulsion System Analysis) is a computer program developed by Lockheed Missiles & Space Company, Inc., as part of the Shuttle Cryogenic Supply System Optimization Study, Contract NAS9-11330, for the NASA, Manned Spacecraft Center. This manual contains a detailed description of the program, its operational characteristics, and computer system requirements.

SOPSA DEVELOPMENT AND UTILIZATION

The SOPSA program was developed by LMSC primarily as an analytical tool to aid in the preliminary design of propellant feed systems for the Space Shuttle Orbiter main engines. The primary purpose of the SOPSA program is to evaluate propellant tank ullage pressure requirements imposed by the need to accelerate propellants rapidly during the engine start sequence. These requirements can influence the system design for a given engine as well as the suitability of a given system for use with different engines. During the vehicle design phase, the SOPSA program is used to establish feed system weight variations as a function of nominal line diameter and component and line configurations. The weight data are used in conjunction with pertinent cost data to establish optimum feed system designs.

The SOPSA program will generate parametric feed system pressure histories and weight data for a range of nominal feedline sizes. This is accomplished by evaluating tank ullage pressure requirements during the startup phase using the constraints of engine inlet pressure (or NPSP) requirements and instantaneous values of feedline flow resistance. Program flexibility has been incorporated to allow for engine start on the ground or at altitude, computations for oxidizer, fuel or both oxidizer and fuel feedlines,

and a multiple restart capability requiring restart data input only for quantities whose values have changed from the previous case.

The SOPSA program utilizes a simple, in-line computational sequence to solve for the propellant tank ullage pressure requirements. Input data describe the number of main propellant feedline sizes to be considered, and the number of engine feedlines attached to each main feedline (i.e., the number of branch lines feeding each engine). The number and type of components in each line are described, with up to 23 line components currently being available. These components include straight and curved line sections, valves, bellows, venturis and PVC's. (The program computes component weights and flow resistance coefficients and display total values for each line as part of the output data.) Engine flowrate, NPSP and thrust profiles during the startup transient are also input. In addition propellant tank geometry and propellant and vehicle weights are required, along with input data control flags and miscellaneous boundary conditions. The program will compute the various pressure drop components needed to evaluate tank pressure requirements during engine start. These calculations are performed for each candidate main feedline size (engine feedline sizes assumed fixed) as a function of time throughout the start transient. Feedline weights are computed based on the maximum value of engine inlet pressure, the maximum value of tank bottom pressure, or an input design pressure, which ever is greatest.

The output data display consists of reformatted input data, feedline flow resistance coefficients, time-varying values of the pressure drop components to hydrostatic head, flow acceleration, and line friction and configuration losses. Computed values of nominal and minimum required values of tank ullage pressure are displayed, as well as tank bottom and engine inlet pressures. Total feedline system weights are also output for each candidate main feedline size.

In summary, the present SOPSA capabilities are as follows:

- Performs pressure drop calculations for up to four engines per main feedline.
- Handles up to 12 candidate main feedline sizes per engine.
- Computes component weight and flow resistance for up to 100 components in each feedline.
- Input options available to describe 23 types of components, 7 material types, and 6 insulation types.
- Operates on the UNIVAC 1108 computer utilizing the EXEC 8 operating system.
- Approximate computer run time is 6 seconds per case.

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Section 1

SOPSA PROPELLANT FEED SYSTEM ANALYSIS PROGRAM

A major consideration in the design of propellant tanks and feed systems for the Space Shuttle Orbiter vehicle is the requirement that propellants be accelerated rapidly during the engine start sequence. Propellant tank structural design is influenced by the maximum ullage pressure levels required to provide sufficient flow acceleration, as well as hydrostatic pressure levels incurred during boost. Flow acceleration requirements, in turn, are dictated by pressure levels required to provide specified propellant flowrates at the engine during startup, while simultaneously satisfying minimum NPSP and inlet pressure requirements. Propellant feed system weight and flow resistance are influenced by component size and design pressure levels. Thus optimization of feed system design requires values of tank ullage pressure as a function of feedline diameter as well as feed system weight. The SOPSA program is designed to compute required pressure values and feed system weights for a range of main feedline diameters.

The SOPSA program consists of a main program (STAR), in which the basic pressure drop calculations are performed, and 16 subprograms which provide thermodynamic property data and perform auxiliary computations. The main program also controls the input of data and the output of computed results.

The UNIVAC 1108-Procedure Definition Processor (PDP) is used to define two blocks of FORTRAN code which are introduced into the main program (and selected subprograms) during compilation by use of the source control statement INCLUDE. The first PDP element is named DIMN and contains CØMMØN statements for labeled CØMMØN block DIMEN, as well as REAL and EQUIVALENCE statement definitions.

The second PDP element is named UCØNST and contains only the CØMMØN block labeled UCØNST.

The variables defined in these CØMMØN blocks are described in Section 1.1.3 below.

1.1 PROGRAM STAR

1.1.1 Program Description

STAR is the SØPSA main program; all data input and output is controlled by STAR and the solution of the time-varying pressure drop components is accomplished in STAR.

Required values of propellant tank ullage pressures during engine start are determined by the pressures required to accelerate the propellant at the rate necessary to supply required flowrates at the engine. A proper accounting of the system pressure drops yields the following relation for ullage pressure requirement at any time t during the start transient:

$$P_u(t) = P_{min} - \Delta P_{HEAD}(t) + \Delta P_F(t) + \Delta P_{ACC}(t) + P_{TOL} \qquad (1)$$

where

P_{min} = Maximum value of $\left\{ \begin{matrix} P_{NPSP} + P_{VAP} \\ \text{or} \\ P_{ENG} \end{matrix} \right\}$

P_{NPSP} = Engine NPSP requirement

P_{VAP} = Propellant vapor pressure at engine inlet

P_{ENG} = Minimum engine inlet pressure

ΔP_{HEAD} = Hydrostatic pressure at engine inlet due to vehicle acceleration

ΔP_F = Pressure drop due to friction in main feedline and engine feedlines

ΔP_{ACC} = Pressure drop required to accelerate propellant to meet the specified flowrate variation during startup

P_{TOL} = Component pressure control tolerance

The pressure control tolerance is generally interpreted to be a combined tolerance on ullage pressure controls and engine inlet requirements.

Equation (1) is solved for an assumed feedline configuration employing a single main feedline for each propellant with up to four branching engine feedlines. Feed systems employing dual main feedlines can be analyzed by restarts or separate runs. Currently, the program is restricted to consider liquid oxygen as the oxidizer and liquid hydrogen as the fuel. An input data flag (SYSNUM) is used to specify whether computations are to be performed for the oxidizer system, fuel system or both feed systems. A ground start flag (NGST) is used to distinguish between engine start on the ground ($g/g_o = 1.0$) or at altitude (g/g_o - Total Thrust/Vehicle Mass) for purposes of hydrostatic head computations.

Inputs to the program are required to:

- Describe the alphanumeric output heading for each case
- Flag data groups to be input
- Describe the propellant tank and feed system configuration
- Describe initial propellant loadings and nominal flow conditions
- Describe transient flowrate, pressure and engine inlet requirements

Input requirements are described in detail in the Space Shuttle Orbit Injection Propulsion System Analysis (SOPSA), User's Manual, LMSC-A991396.

Printed output data include a listing of several input data quantities as follows:

Total number of feedline sizes, NSIZE
Total number of engines on vehicle, NØP1
Number of engines for each feed system, NØP
Nominal oxidizer flowrate, WDØTNØ, lb/sec
Nominal fuel flowrate, WDØTNH, lb/sec
Vehicle loaded weight, VWGTN, lb

Nominal thrust for each engine, FNØM, lb
Oxygen engine inlet temperature, TENINØ, R
Hydrogen engine inlet temperature, TENINH, R
Component pressure tolerance, PENTØL, Psi
Oxidizer feedline head height, ØXHTLN, ft
Fuel feedline head height, HYHTLN, ft
Initial oxidizer loading, LØADØ1, lb
Initial fuel loading, LØADH1, lb
Oxygen feedline design pressure, PDLØ, psia
Hydrogen feedline design pressure, PDLH, psia
Tank geometry data, EQLR1, ft
Oxidizer feedline diameters, ØPD, inches
Hydrogen feedline diameters, HPD, inches
Main oxygen feedline lengths, TØTMLØ, ft
Main hydrogen feedline lengths, TØTMLH, ft

In addition, computer values of oxidizer and fuel head heights in the propellant tanks (HEADIØ and HEADIH), initial ullage volumes (ULVLIØ and ULVLIH), external surface areas of the propellant tanks (ASKIN), surface area of the common bulkhead (ADØME) total tank surface area (ATØT), and feedline flow-resistance coefficients (ØKPD and HKPD) are printed.

Input values of component descriptors are listed in the following order:

	Comp. Seq. No.	Component Type Flag	Material Flag	Insulation Flag	Spec. No. 1	Spec. No. 2
Oxidizer Main Line	I	IDMLØ(I)	IMMLØ(I)	IIMLØ(I)	SPIMLØ(I)	SP2MLØ(I)
Oxidizer Engine Line	I	IDELØ(NL,I)	IMELO(NL,I)	IIELO(NL,I)	SPIELO(NL,I)	SP2ELO(NL,I)
Fuel Main Line	I	IDMLH(I)	IMMLH(I)	IIMLH(I)	SPIMLH(I)	SP2MLH(I)
Fuel Engine Number NL	I	IDELH(NL,I)	IMELH(NL,I)	IIELH(NL,I)	SPIELH(NL,I)	SP2ELH(NL,I)

In addition to the basic fixed input data, values of time-varying input quantities are output. These include the following variables:

Time during engine start, TIMEA, sec
Oxidizer suction pressure requirement, NPSPØ, psi
Fuel suction pressure requirement, NPSPH, psi
Fraction of steady-state engine thrust, FIFRAC
Engine inlet oxidizer pressure requirement PENMNØ, psia
Engine inlet fuel pressure requirement, PENMNH, psia
Partial pressure of pressurant gas in oxidizer tank, PPDGØT, psia
Partial pressure of pressurant gas in fuel tank, PPDGHT, psia
Inlet temperature of pressurant gas in oxidizer tank, TDGØT, R
Inlet temperature of pressurant gas in fuel tank, TDGHT, R

Values of several quantities obtained at intermediate stages of the pressure drop computations are also output as a function of time.

These quantities include:

Oxidizer flowrate derivatives, WDDØTØ, lb/sec^2
Fuel flowrate derivatives, WDDØTH, lb/sec^2
Total vehicle weight, VWGTNU, lb
Thrust-to-weight ratio, FTØW
Oxidizer hydrostatic pressure heat at engine inlet due to vehicle acceleration, DLPHDØ, psi
Incremental oxidizer consumption, PCWGTØ, lb
Incremental fuel consumption, PCWGTH, lb
Cumulative total propellant consumption, PRØWGT, lb
Minimum oxidizer engine inlet pressure required, PENGØ, psia
Minimum fuel engine inlet pressure required, PENGH, psia

Additional intermediate output inclues pressure drop components as follows:

Pressure drop required to accelerate oxidizer to meet specified flowrates, DLPACØ, psi

Pressure drop required to accelerate fuel to meet specified flowrates, DLPACH, psi

Oxidizer pressure drop due to line friction and configuration losses, DLPLNØ, psi

Fuel pressure drop due to line friction and configuration losses, DLPLNH, psi

Nominal ullage pressure requirements in oxidizer and fuel tanks, respectively (without accounting for minimum engine inlet requirements), PULLØ and PULLH, psia

Oxidizer and fuel vapor pressures at the liquid surfaces, PULVAPØ and PULVAPH, psia

Minimum oxidizer and fuel ullage pressures required for main feedline No. 1, PULLRØ (NELP) and PULLRH (NELP), psia

Tank bottom pressures for feedline No. 1, PTKBTØ (NELP), and PTKBTH (NELP), psia

Line head pressure components, PHDLNØ and PHDLNH, psia

Tank ullage volumes, ULVLØ2 and ULVLH2, ft^3

Tank head heights, HEADØ2 and HEADH2, ft

Ullage vapor weights, WTULGØ and WTULGH, lb

The final computations are printed in the following order.

Minimum required ullage pressure in oxidizer tank, PULLRØ, psia

Minimum required ullage pressure in fuel tank, PULLRH, psia

Recomputed tank bottom pressures using minimum required ullage pressures, PTKBTØ and PTKBTH, psia

Recomputed engine inlet pressures using minimum required ullage pressures, PENNUØ and PENNUH, psia

Individual engine feedline weights, WELØ and WELH, lb

Total weights of all engine feedlines, WELØT and WELHT, lb

Main feedline weights, WMLØ and WMLH, lb

Engine and main feedline insulation weights, WELIØT, WELIHT, WMLIØ, WMLIH, lb

Total feed system weights, WLØTT and WLHTT, lb

1.1.2 External Subprograms

Name	Type*	Reference**	Name	Type	Reference
MOVER	S		ZFIND	S	
INIVOL	S		FINDR	F	
ULLHED	S		PTDENS	F	
FLORES	S		WTCTRL	S	
PVAPOR	S		EXIT	S	Transfer control to system

1.1.3 COMMON Description

The COMMON block labeled DIMEN is INCLUDEd in the main program STAR and subroutines INIVOL and ULLHED. This block contains the following variables:

Name	Type***	Dimension	Description
EQLR	R	9	Array containing tank geometry data
V1	R		Volumes of sections of liquid oxygen tank
V2	R		
V3	R		
V4	R		
V5	R		Volumes of sections of liquid hydrogen tank
V6	R		
V7	R		

*P - Program, S - Subroutine, F - Function
**Page number where subprogram is described
***I - Integer, R - Real, L - Logical

Name	Type	Dimension	Description
VTØ2	R		Total volume LO_2 tank
VTH2	R		Total volume LH_2 tank
VTØT	R		Total volume both tanks
UVLØ2	R		Ullage volume LO_2 tank
UVLH2	R		Ullage volume LH_2 tank
HDØ2	R		Liquid height in LO_2 tank
HDH2	R		Liquid height in LH_2 tank
A1	R		Surface area of sections of LO_2 tank
A2	R		
A3	R		
A4	R		
A6	R		Surface area of sections of LH_2 tank
A7	R		
ATØT	R		Total surface area of both tanks
ASKIN	R		External surface area of both tanks
ADØME	R		Area of common bulkhead

The CØMMØN block labeled UCØNST is INCLUDEd in the main program STAR and subroutines ULLHED, GØMTRY and SPHSEG. This block contains the following variables:

Name	Type	Dimension	Description
IIN	I		Hardware logical input unit number
IØT	I		Hardware logical output unit number
PI	R		3.1415927
PI2Ø3	R		2.0943951

Seven additional labeled CØMMØN blocks contain the significant variables used in the main program. Storage allocated for these variables is described in Tables 1-1 through 1-7.

Table 1-1
LAYOUT OF COMMON BLOCK AAA

Address(1)	Name	Dimension(2)	Description
0	FIFRAC	21	Fraction of nominal thrust
25	TIMEA	21	Time values of events in transient
52	WDTFRO	21	Fraction of oxidizer flowrate
77	WDTFRH	21	Fraction of fuel flowrate
124	NPSPO	21	Net positive suction pressurefor oxidizer
151	NPSPH	21	Net positive suction pressure for fuel
176	PPDGOT	36	Partial pressure of oxidizer pressurant gas
242	PPDGHT	36	Partial pressure of fuel pressurant gas
306	TLIQSO		Temperature of oxid zer liquid surface in tank
307	TLIQSH		Temperature of fuel liquid surface in tank
310	TSVAPO		Temperature of oxidizer liquid surface in tank
311	TSVAPH		Temperature of fuel liquid surface in tank
312	TDGOT	35	Temperature of oxidizer pressurant gas
355	TDGHT	35	Temperature of fuel pressurant gas
420	LOADO1		Loaded weight of oxidizer
421	LOADH1		Loaded weight of fuel
422	LOADO2		Loaded volume of oxidizer
423	LOADH2		Loaded volume of fuel

Table 1-2
LAYOUT OF COMMON BLOCK BBB

Address	Name	Dimension	Description
0	NSIZE		Total number of feedlines per tank
1	SYSNUM		Propellant selection flag
2	NOP		Number of engines fed by a main feedline
3	NOP1		Number of engines on vehicle
4	IGOON		Restart flag
5	NPTS		Number of time points in start transient
6	MPTS		NPTS-1

Note: (1) Address in octal notation
(2) Decimal dimension

Table 1-3
LAYOUT OF COMMON BLOCK CCC

Address	Name	Dimension	Description
0	GC		Acceleration of gravity, 32.172 fps^2
1	RHOOX		Oxidizer density
2	RHOHY		Fuel density
3	VWGTN		Total vehicle weight at ignition

Table 1-4
LAYOUT OF COMMON BLOCK DDD

Address	Name	Dimension	Description
0	WDOTNO		Nominal oxidizer flowrate per engine
1	WDOTNH		Nominal fuel flowrate per engine
2	FNOM		Nominal thrust per engine
3	OPIPEL	16	Oxidizer feedline lengths
2	HPIPEL	16	Fuel feedline lengths
43	OPD	16	Oxidizer feedline diameters
63	HPD	16	Fuel feedline diameters
103	OKPD	16	Oxidizer feedline flow resistance coefficients
123	HKPD	16	Fuel feedline flow resistance coefficients
143	ST	7	Alphanumeric title
152	OXHTLN		Oxidizer lead height in feedline
153	HYHTLN		Fuel lead height in feedline
154	PENMNO	30	Minimum engine inlet oxidizer pressures
212	PENMNH	30	Minimum engine inlet fuel pressures
250	PENTOL		Component pressure tolerance
251	TENINO		Temperature of oxidizer at engine inlet
252	TENINH		Temperature of fuel at engine inlet

Table 1-5
LAYOUT OF COMMON BLOCK EEE

Address	Name	Dimension	Description
0	OPDUM		Oxidizer line length used in acceleration calcs.
1	ODDUM		Square of oxidizer line diameter
2	HPDUM		Fuel line length used in acceleration calcs.
3	HDDUM		Square of fuel line diameter
4	VWGTCH		Variable used in vehicle weight calculations
5	ODLDUM		Fourth power of oxidizer line diameter
6	OCAYP		Variable used in pressure drop calculations
7	ODTINC		Not used
10	HDLDUM		Fourth power of fuel line diameter
11	HCAYP		Variable used in pressure drop calculations
12	HDTINC		Not used
13	TVAPO		Equivalent oxidizer engine inlet temperature
14	TVAPH		Equivalent fuel engine inlet temperature
15	PVAPO		Oxidizer vapor pressure
16	PVPENO		Oxidizer vapor pressure at engine inelt
17	PVAPH		Fuel vapor pressure
20	PVPENH		Fuel vapor pressure at engine inlet
21	PNCWGT		Equivalent cumulative propellant consumption

Table 1-6
LAYOUT OF COMMON BLOCK FFF

Address	Name	Dimension	Description
0	WDDOTO	20	Oxidizer flowrate derivative
24	WDDOTH	20	Fuel flowrate derivative
50	ZLPACO	20	Not used
74	ZLPACH	20	Not used
120	VWGTNU	20	Vehicle weight
144	FTOW	20	Thrust-to-weight ratio
170	DIFWGT	20	Propellant flowrate increment
214	DLPHDO	20	Oxidizer pressure head in tank
240	DLPHDH	20	Fuel pressure head in tank
264	ZLPLNO	20	Not used
310	ZLPLNH	20	Not used
334	PENGO	20	Minimum oxidizer engine inlet pressure
360	PENGH	20	Minimum fuel engine inlet pressure
404	PCWGTO	20	Incremental oxidizer consumption
430	PCWGTH	20	Incremental fuel consumption
454	PUVAPO		Oxidizer vapor pressure at liquid surface
455	PSVAPO		(Same as PUVAPO)
456	PUVAPH		Fuel vapor pressure at liquid surface
457	PSVAPH		(Same as PUVAPH)
460	PPVAPO		Not used
461	PPVAPH		Not used
462	ULVLIO		Initial ullage volume in oxidizer tank
463	ULVLIH		Initial ullage volume in fuel tank
464	HEADIO		Oxidizer head height in the tank
465	HEADIH		Fuel head height in the tank

Table 1-7
LAYOUT OF COMMON BLOCK GGG

Address	Name	Dimension	Description
0	WTULGO	35	Oxidizer tank ullage vapor weight
43	WTULGH	35	Fuel tank ullage vapor weight
106	ULVO2		Not used
107	ULVH2		Not used
110	HEADO2	35	Oxidizer tank head height
153	HEADH2	35	Fuel tank head height
216	ULVLO2	35	Oxidizer tank ullage volume
261	ULVLH2	35	Fuel tank ullage volume

1.1.4 Significant Variables

In addition to the variables defined in Tables 1-1 through 1-7, the following quantities are significant in the operation of program STAR:

Name	Type	Dimension	Description
IP	I	16	Input data flag
WELØT	R	16	Total oxidizer engine feedline weight
WELHT	R	16	Total fuel engine feedline weight
UMLØ	R	16	Main oxidizer feedline weight
WMLH	R	16	Main fuel feedline weight
WLØTT	R	16	Total oxidizer feed system weight
WLHTT	R	16	Total fuel feed system weight

1.1.5 Tape Usage

No tapes are used by this program.

1.1.6 Flow Chart and Listing Reference

1.1.7 Subprogram Descriptions

Each subprogram of STAR will be described using the following format:

Description

Description will briefly describe the subprogram.

Calling Sequence

Calling Sequence will contain the following elements:

Name	Type	I/O	Dimension	Description

Name is the name of the variable in the calling sequence.

Type indicates the type of the variable; I - integer, R - real, or L - logical.

I/O indicates if the variable is input (I) to the routine through the calling sequence, output (O) from this routine through the calling sequence, or I/O if both.

Significant Variables

Significant Variables will contain the following elements:

Name	Type	Dimension	Description

The elements of Significant Variables will be as described under Calling Sequence.

Subprograms Referenced in this Subprogram

Name	Type	Reference

The elements of Subprograms Referencing this Subprogram will be the same as described under Subprograms Referenced in this Subprogram.

Flow Chart and Listing Reference

Flow Chart references the figure number of the applicable flow chart. Appendix A illustrates and explains the flow chart symbols.

Listing references include the page numbers of the SØPSA listings and subroutine dictionary listings where the subroutine listing, variable table, statement number table, and transfer table may be found.

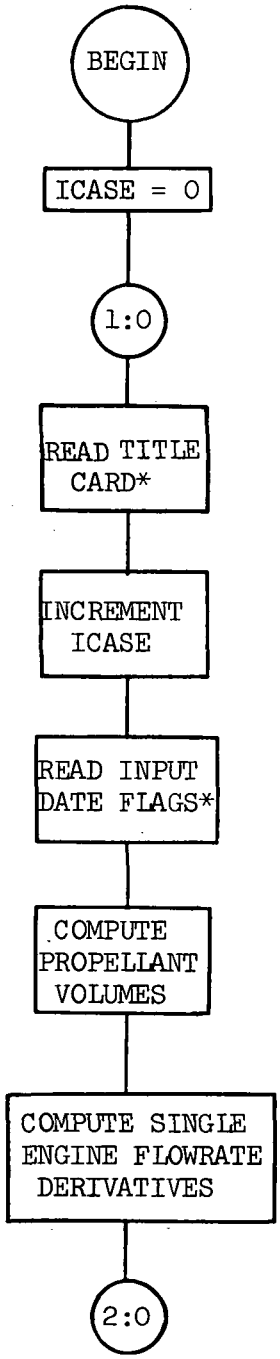


Fig. 1-1 STAR Flow Chart

*NOTE: TITLE CARD AND INPUT DATA FLAG CARD ARE REQUIRED FOR EACH CASE. THE REMAINING DATA MUST BE SUPPLIED FOR THE FIRST CASE; SUBSEQUENT CASES (RESTARTS) REQUIRE ONLY THAT REVISED DATA GROUPS BE INPUT (SEE SOPSA USER'S MANUAL, PAGE).

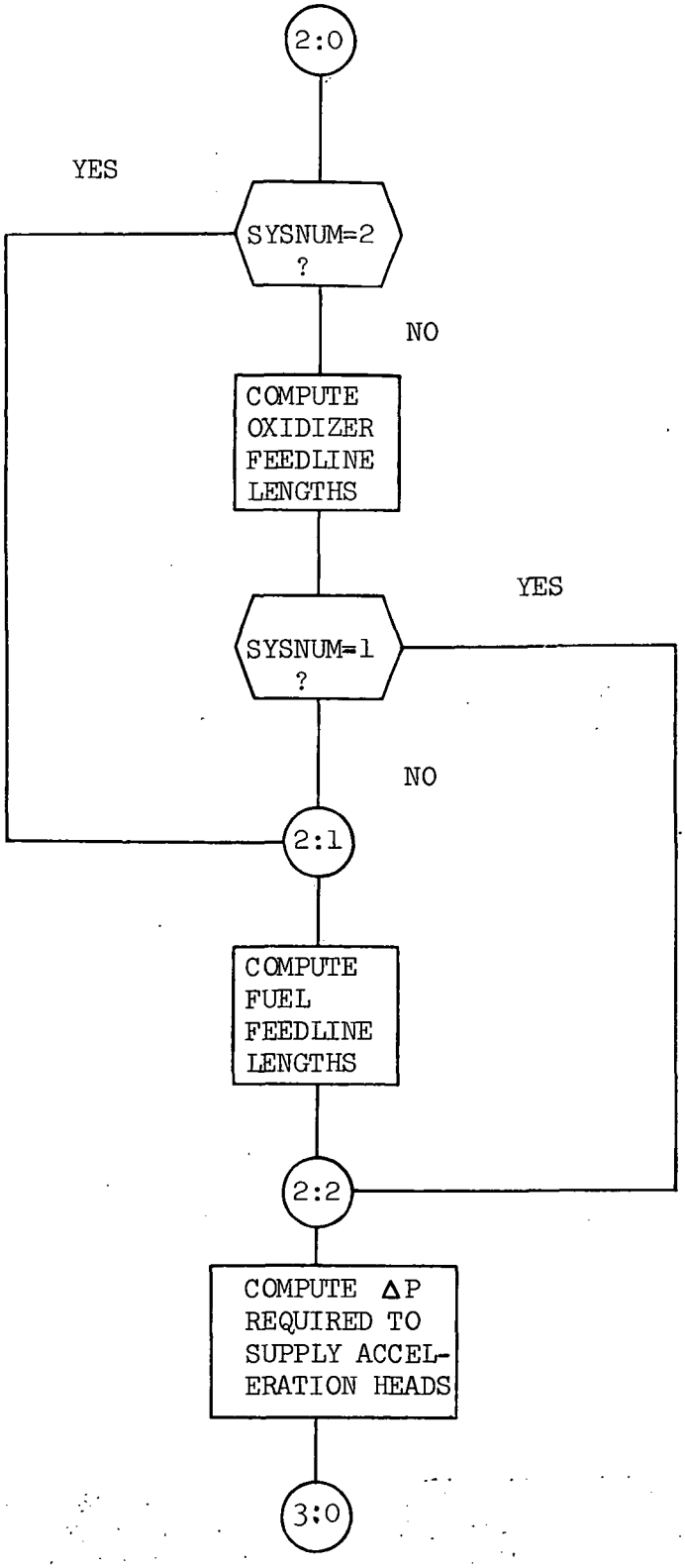


Fig. 1-1 STAR Flow Chart (Cont'd)

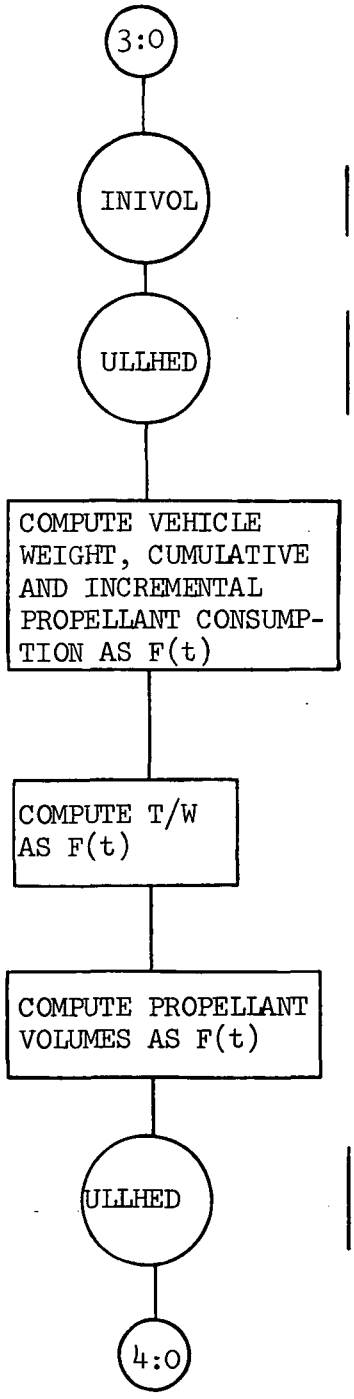


Fig. 1-1 STAR Flow Chart (Cont'd)

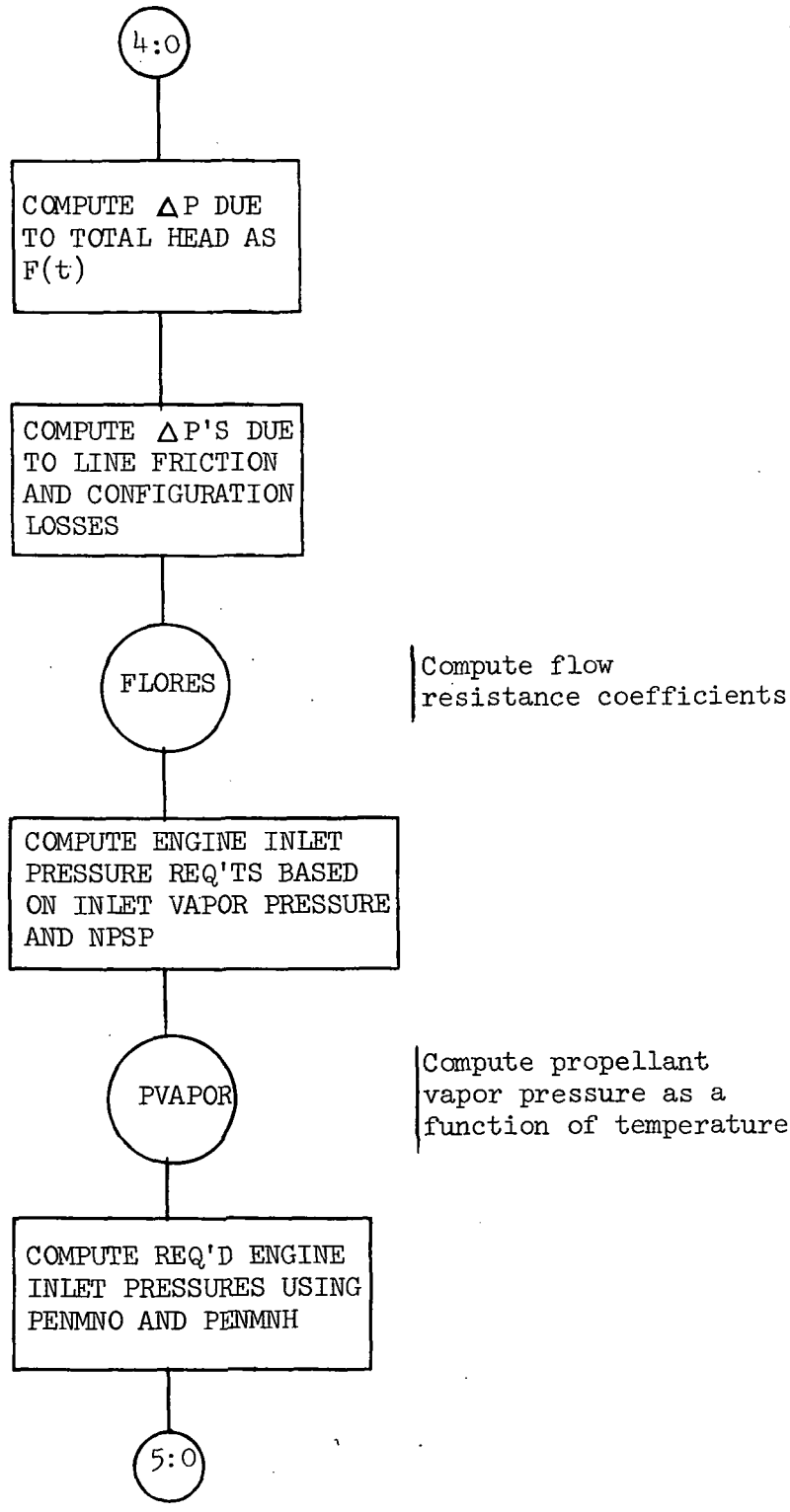
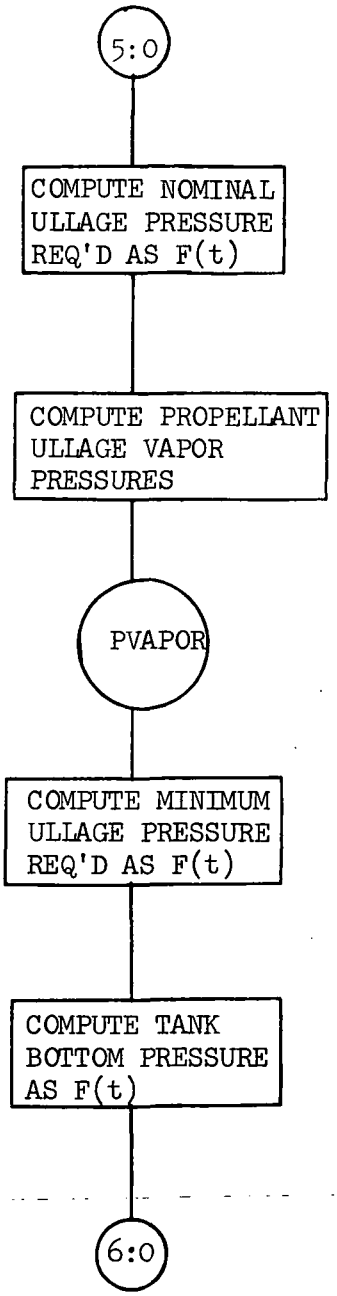


Fig. 1-1 STAR Flow Chart (Cont'd)



Compute propellant vapor pressure as a function of temperature

Fig. 1-1 STAR Flow Chart (Cont'd)

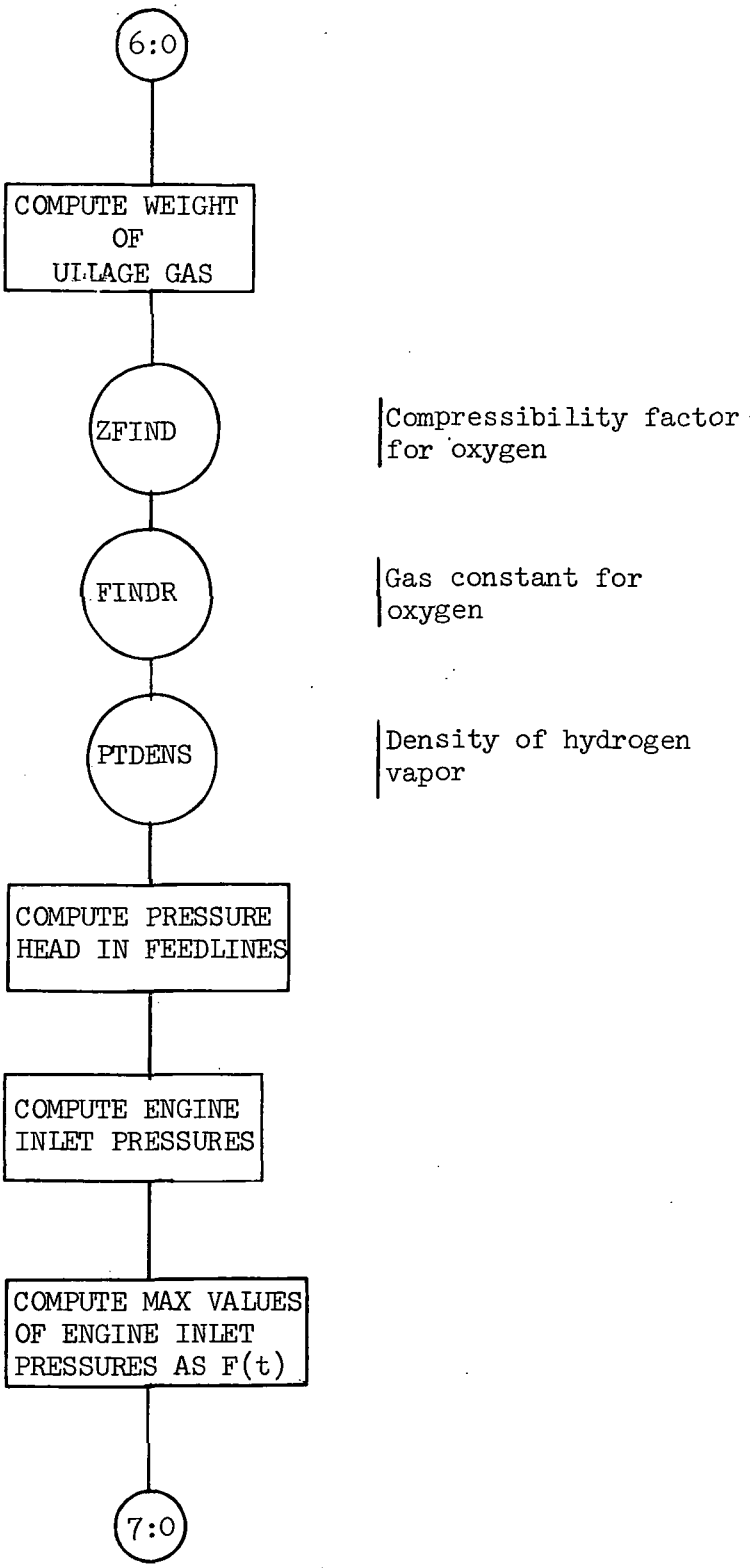


Fig. 1-1 STAR Flow Chart (Cont'd)

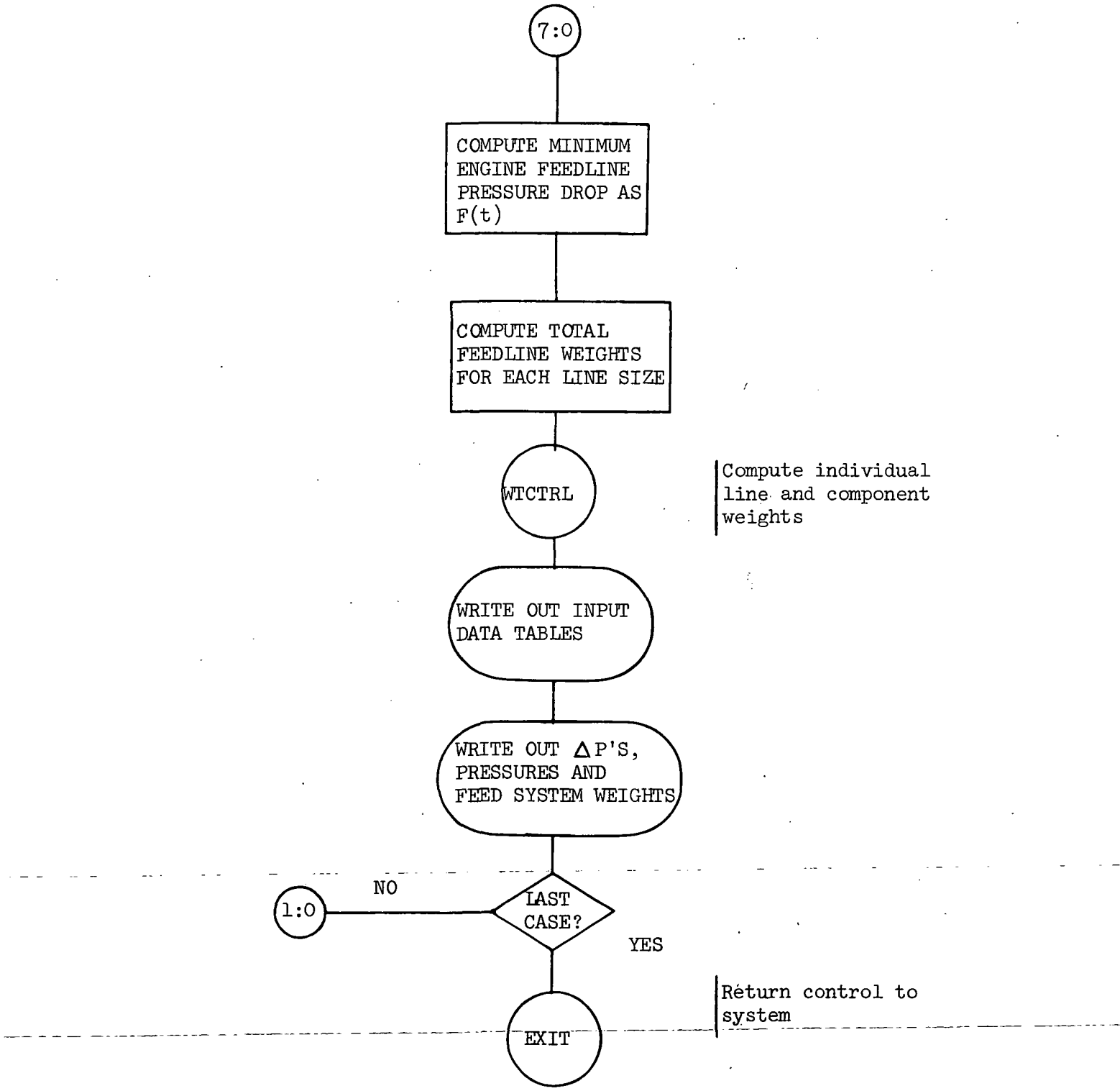


Fig. 1-1 STAR Flow Chart (Cont'd)

1.1.7.1 Subroutine INIVOL

Description

Subroutine INIVOL computes the volume and surface areas of individual sections of the propellant tanks using the dimensions supplied in input data group 2. The individual volumes and areas are summed for each tank and the total external surface area is computed.

Calling Sequence

```
CALL  INIVØL
```

Significant Variables

Name	Type	Dimension	Description
VTO2	R		Volume oxygen tank
VTH2	R		Volume hydrogen tank
VTØT	R		Total tank volume
ASKIN	R		External surface area
ADØME	R		Area of common bulkhead

Subprograms Referenced in this Subprogram

Name	Type	Reference
GØMTRY	F	38

Subprograms Referencing this Subprogram

Name	Type	Reference
STAR	P	6

Flow Chart and Listing Reference

INIVOL Flow Chart	None
INIVOL Program Listing	Page B-27
Variable Table	Page C-16
Statement Number Table	None
Transfer Table	Page C-17

1.1.7.2 Subroutine ULLHED

Description

This subroutine uses the given values of propellant volumes and tank dimensions to compute ullage volumes and liquid head heights in the tanks.

Calling Sequence

CALL ULLHED (LØAD02, LØADH2)

Name	Type	I/O	Dimension	Description
LØADØ2	R	I		Oxidizer volume
LØADH2	R	I		Fuel volume

Significant Variables

Name	Type	Dimension	Description
UVLØ2	R		Oxidizer ullage volume
UVLH2	R		Full ullage volume
HDØ2	R		Oxidizer head height
HDH2	R		Fuel head height

Subprograms Referenced in this Subprogram

Name	Type	Reference
SPHSEG	S	41

Subprogram Referencing this Subprogram

Name	Type	Reference
STAR	P	1-2

Flow Chart and Listing Reference

ULLHED Flow Chart	None
ULLHED Program Listing	Page B- 8
Variable Table	Page C-16
Statement Number Table	Page C-20
Transfer Table	Page C-21

1.1.7.3 Subroutine FLORES

Description

This subroutine uses empirical correlations for pressure drop in turbulent flow (Reynold's No. greater than 10^6) to compute flow resistance coefficients due to configuration losses for the configurations defined in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

CALL FLØRES (ID, D, S1, S2, RES)

Name	Type	I/O	Dimension	Description
ID	I	I		Component ID number
D	R	I		Diameter
S1	R	I		Component specification No. 1
S2	R	I		Component specification No. 2
RES	R	O		Flow resistance factor

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
STAR	P	6

Flow Chart and Listing Reference

FLORES Flow Chart	None
FLORES Program Listing	Page B-29
Variable Table	Page C-22
Statement Number Table	Page C-23
Transfer Table	Page C-24

1.1.7.4 Subroutine PVAPOR

Description

Subroutine PVAPOR computes the saturation vapor pressure of a liquid given the value of liquid temperature.

Calling Sequence

```
CALL PVAPØR (T, I, P)
```

Name	Type	I/O	Dimension	Description
T	R	I		Liquid temperature
I	I	I		Fluid type flag, I = 1 for oxygen I = 2 for hydrogen
P	R	O		Vapor pressure

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
STAR	P	6
ZFIND	S	31

Flow Chart and Listing Reference

PVAPOR Flow Chart	None
PVAPOR Program Listing	Page B-32
Variable Table	Page C-25
Statement Number Table	Page C-26
Transfer Table	Page C-27

1.1.7.5 Subroutine ZFIND

Description

Subroutine ZFIND computes the compressibility of a gas given its temperature and pressure.

Calling Sequence

CALL ZFIND (T, P, N, V)

Name	Type	I/O	Dimension	Description
T	R	I		Temperature
P	R	I		Pressure
N	I	I		Gas type flag, N = 1 for oxygen, N = 2 for hydrogen.
V	R	O		Compressibility factor

Significant Variables

None

Subprogram Referenced in this Subprogram

Name	Type	Reference
PVAPOR	S	29
PTDENS	F	33

Subprograms Referencing this Subprogram

Name	Type	Reference
STAR	P	6

Flow Chart and Listing Reference

ZFIND Flow Chart	None
ZFIND Program Listing	Page B-33
Variable Table	Page C-28
Statement Number Table	Page C-29
Transfer Table	Page C-30

1.1.7.6 Function FINDR

Description

Function FINDR supplies the gas constant corresponding to an input gas type flag.

Calling Sequence

R = FINDR (N)

Name	Type	I/O	Dimension	Description
N	I	I		Gas type flag, N = 1 for oxygen, N = 2 for hydrogen

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
STAR	P	6

Flow Chart and Listing Reference

FINDR Flow Chart	None
FINDR Program Listing	Page B-35
Variable Table	Page C-31
Statement Number Table	None
Transfer Table	Page C-32

1.1.7.7 Function PTDENS

Description

Function PTDENS returns the density of hydrogen vapor corresponding to input values of vapor pressure and temperature.

Calling Sequence

RHØ = PTDENS (PRES, TEMP)

Name	Type	I/O	Dimension	Description
PRES	R	I		Gas pressure
TEMP	R	I		Gas temperature

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
STAR	P	6
ZFIND	S	31

Flow Chart and Listing Reference

PTDENS Flow Chart	None
PTDENS Program Listing	Page B-36
Variable Table	Page C-33
Statement Number Table	Page C-34
Transfer Table	Page C-35

1.1.7.8 Subroutine WTCTRL

Description

Subroutine WTCTRL uses empirical correlations for weight as a function of nominal size to obtain the weight of components described in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

Call WTCTRL (P, I, IM, II, D, S1, S2, S3, IV, IF, WT, WI)

Name	Type	I/O	Dimension	Description
P	R	I		Internal fluid presssre
I	I	I		Component type flag
IM	I	I		Material flag
II	I	I		Insulation flag
D	R	I		Nominal line diameter
S1	R	I		Component specification No. 1
S2	R	I		Component specification No. 2
S3	R	I		Component specification No. 3
IV	I	I		Valve weight flag
IF	I	I		Fluid type flag
WT	R	O		Component weight
WI	R	O		Insulation weight

Significant Variables

None

Subprograms Referenced in this Subprogram

Name	Type	Reference
CBWT	F	37
CFTW	F	36

Subprogram Referencing this Subprogram

Name	Type	Reference
STAR	P	6

Flow Chart and Listing Reference

WTCTRL Flow Chart	None
WTCTRL Program Listing	Page B-40
Variable Table	Page C-36
Statement Number Table	Page C-37
Transfer Table	Page C-38

1.1.7.9 Function CFTW

Description

Function CFTW computes the weight of valves and disconnects described in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

WT = CFTW (D, P, IDV)

Name	Type	I/O	Dimension	Description
D	R	I		Nominal diameter
P	R	I		Internal pressure
IDV	I	I		Valve type flag

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
WTCTRL	S	34

Flow Chart and Listing Reference

1.1.7.10 Function CBWT

Description

Function CBWT computes the weight of the various types of bellows and pressure-volume compensators described in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

```
WT = CBWT (D, P, IB)
```

Name	Type	I/O	Dimension	Description
D	R	I		Nominal diameter
P	R	I		Internal pressure
IB	I	I		Bellows type flag

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
WTCTRL	S	34

Flow Chart and Listing Reference

CBWT Flow Chart	None
CBWT Program Listing	Page B-43
Variable Table	Page C-42
Statement Number Table	Page C-43
Transfer Table	Page C-44

1.1.7.11 Function GOMTRY

Description

Function GOMTRY computes the volume and/or area of a variety of geometrical surface of revolution. This function consists of a variety of subfunctions each of which is accessed by an ENTRY whose name describes the geometrical figure desired.

Calling Sequence

The calling sequence for functions of each type of surface is as follows:

Volume of Circular Cone

```
V = CONE (R, H)
```

Name	Type	Description
R	R	Radius of base of cone
H	R	Height of cone

Volume of Right-Circular Cylinder

V = CYLNDR (R,H)

Name	Type	Description
R	R	Radius of cylinder
H	R	Height of cylinder

Volume Contained Between Cylinder and Spheroid

V = CYLSPH (RRØT,R)

Name	Type	Description
RRØT	R	Height of cylinder (spheroid)
R	R	Radius of cylinder

Volume of Frustum of Right-Circular Cone

V = FRCONE (R, H, R2)

Name	Type	Description
R	R	Radius at top of cone
H	R	Height of cone
R2	R	Radius of base of cone

Volume of Hemisphere or Half-Spheroid

V = HSPHER (RRØT, R)

Name	Type	Description
RRØT	R	Height along axis of rotation
R	R	Radius

Volume of Sphere or Spheroid

V = SPHERE (RRØT,R)

Name	Type	Description
RRØT	R	Height along axis of rotation
R	R	Radius

Area of Cylinder

A = ARACYL (R, H)

Arguments defined as in CYLNDR.

Area of Conical Frustum

A = AFEAFR (R, H, R2)

Arguments defined as in FRCØNE.

Area of Hemi-Spheroid or Hemisphere

A = ARSPHR (RRØT, R)

Arguments defined as in HSPHER.

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

Name	Type	Reference
INIVOL	S	26

Flow Chart and Listing Reference

GOMTRY Flow Chart	None
GOMTRY Program Listing	Page B-44
Variable Table	Page C-45
Statement Number Table	Page C-46
Transfer Table	Page C-47

1.1.7.12 Subroutine SPHSEG

Description

Subroutine SPHSEG computes the height of a given volume of liquid (head height) in an ellipsoid of revolution (including a hemisphere) or in the volume between a cylinder and a spheroid. One of two entries are used depending on the geometry involved.

Calling Sequence

The calling sequence for computing head heights contained in each type of volume is as follows:

Ellipsoidal Volume

H = ELIPSG (PVØL, RAD, RPD, H)

Name	Type	Description
PVØL	R	Ullage vapor volume
RAD	R	Height of ellipse along axis of rotation
RPD	R	Radius
H	R	Liquid head height

Volume Between Cylinder and Spheroid

H = CYMSPH (PVØL, RAD, RPD, H)

Name	Type	Description
PVØL	R	Ullage vapor volume
RAD	R	Height along axis of rotation
RPD	R	Radius of cylinder
H	R	Liquid head height

Significant Variables

None

Subprograms Referencing this Subprogram

Name	Type	Reference
ULLHED	S	27

Flow Chart and Listing Reference

SPHSEG Flow Chart	None
SPHSEG Program Listing	Page B-46
Variable Table	Page C-48
Statement Number Table	Page C-49
Transfer Table	Page C-50

Section 2

PROGRAM OPERATION

Input deck setup and input data requirements for the SOPSA program are described in detail in the SOPSA Program User's Manual. This program has been developed using the EXEC 8 operating system on the UNIVAC 1108 operating system. The SOPSA program can be compiled and executed on comparable systems containing the FORTRAN V utility and standard UNIVAC routines described in Section 4 below.

2.1 NORMAL PROGRAM EXECUTION

During normal operation, the program will read input data, perform the required operations, and print the final results. No intermediate output is provided, so that in the event of an input data error, the user must diagnose the malfunction from the final printed output.

2.2 ABNORMAL PROGRAM EXECUTION

In the event that the program does not produce a final data printout, the user must diagnose the error by rechecking input data types and formats. Diagnostic printouts are provided in two subroutines, ULLHED and SPHSEG. The ULLHED diagnostic is of the form

'ULLAGE VOLUME IS NEGATIVE'

and indicates that input tank geometry data is not compatible with the specified propellant loading.

The SPHSEG diagnostic is of the form

'ERROR INPUT TO SPHSEG'

and indicates that input tank geometry data are not correct.

Section 3

LIBRARY ROUTINES

The SOPSA program uses both Lockheed system routines and FORTRAN utility routines, in addition to the UNIVAC 1108, EXEC 8, system routines.

3.1 LOCKHEED SYSTEM ROUTINES

The Lockheed system contains a standard library of FORTRAN V mathematical function routines, of which the following are used by SOPSA:

SQRT	Square root
EXP	Exponential
CPS	Cosine
ASIN	Arcsine
ACOS	Arccosine
ATAN	Arctangent
ALOG	Natural logarithm (log x)

3.2 FORTRAN UTILITY ROUTINES

3.2.1 Subroutine MOVER

The subroutine MOVER is available to permit rapid transfer of data words from one area to another. The 1108 block transfer is used; thus, the use of MOVER will be considerably faster than a corresponding transfer of data by a DO-loop. It is used as follows:

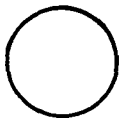
```
CALL MOVER (FROM, INCF, TO, INCT, NWDS)
```

where

FROM	is the array from which data are moved.
INCF	is the increment to be used in selecting data from the FROM array.
TO	is the array to which data are moved.
INCT	is the increment to be used in placing data into the TO array.
NWDS	is the number of words to transfer.

NOTE: MOVER checks to see if the argument NWDS is negative. It it is, the run is "errored off."

APPENDIX A
FLOW CHART SYMBOLS

SYMBOL	DEFINITION
	Subprogram Reference
	Processing Function
	Step Connector
	Program Modification or Decision Function

APPENDIX B
SOPSA PROGRAM LISTINGS

This Appendix contains a symbolic listing of the FORTRAN V code for the SOPSA main program and subprograms.

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```
      C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *STAR0001
      C     *                                                               *STAR0002
      C     *        **  ENGINE START TRANSIENT ANALYSIS PROGRAM  **        *STAR0003
      C     *                                                               *STAR0004
      C     *          **  THE PROGRAM I.D. CODE IS  -  FD1306  **          *STAR0005
      C     *                                                               *STAR0006
      C     *    PROGRAMMED BY R.F.HAUSMAN, DEPT 62-13, BLDG 104, 3-0235    *STAR0007
      C     *    REVISED BY R.M. VERNON, DEPT. 62-03, BLDG 562, 24385       *STAR0008
      C     *                                                               *STAR0009
      C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *STAR0010
      C                                                                      STAR0011
      C                                                                      STAR0012
            INCLUDE DIMN.LIST                                              STAR0013
            INCLUDE UCONST.LIST                                            STAR0014
            DIMENSION DFWGT(20),FTOW(20),DLPHDO(20),DLPHDH(20),VWGTNU(20)  STAR0015
            DIMENSION DFWGTO(20),DFWGTH(20),PCWGTO(20),PCWGTH(20)          STAR0016
            DIMENSION EGLR1(9)                                             STAR0017
            DIMENSION FIFRAC(21),TIMEA(21),WDTFRC(21),WDTFRH(21)           STAR0018
            DIMENSION HEADO2(35),HEADH2(35)                                STAR0019
            DIMENSION HPO(16),HP1PEL(16),HKPO(16),CPO(16),OP1PEL(16),OKPO(16) STAR0020
            DIMENSION P1(1),GC(1),RHOOX(1),RHOHY(1),VWGTN(1),FNOM(1)       STAR0021
            DIMENSION PENGO(20),PENGH(20),NPSPO(21),NPSPH(21)              STAR0022
            DIMENSION PENMNO(30),PENMNH(30)                                STAR0023
            DIMENSION TDSOT(35),TDSHT(35)                                  STAR0024
            DIMENSION TENINO(1),TENINH(1)                                  STAR0025
            DIMENSION TLIQSO(1),TLIQSH(1),PPDSOT(36),PPDSHT(36)            STAR0026
            DIMENSION VL302(35),VL3H2(35),LLVL02(35),ULVLH2(35)            STAR0027
            DIMENSION WDOTNO(1),WDOTNH(1),CXHTLN(1),HYHTLN(1),ST(7)        STAR0028
            DIMENSION WDDOTO(20),WDDOTH(20)                                STAR0029
            DIMENSION WTULSO(35),WTULSH(35)                                STAR0030
            DIMENSION ZLPACO(20),ZLPACH(20),ZLPLNO(20),ZLPLNH(20),PROWGT(20) STAR0031
            DIMENSION DLPACO(16,20),DLPACH(16,20)                          STAR0032
            DIMENSION DLPLNO(16,20),DLPLNH(16,20)                          STAR0033
            DIMENSION PENNJO(16,35),PENNUH(16,35),PENMUO(16,35),PENMUH(16,35) STAR0034
            DIMENSION PULLO(16,20),PULLH(16,20)                            STAR0035
            DIMENSION PTKBTO(16,35),PTKBTH(16,35),PHDLNO(35),PHDLNH(35)    STAR0036
            DIMENSION PULMNO(35),PULLRO(16,35),PULMNH(35),PULLRH(16,35)    STAR0037
            DIMENSION SP3M_O(100),SP3ELO(4,100),SP3MLH(100),SP3ELH(4,100)  STAR0038
            DIMENSION WMLIO(16),WELIO(16,4),WELICT(16),WLIOT(16),WLOTT(16) STAR0039
            DIMENSION WMLIH(16),WELIH(16,4),WELIHT(16),WLIHT(16),WLHTT(16) STAR0040
            DIMENSION IP(15)                                               STAR0041
            DIMENSION MIDE_O(4),IDMLO(100),IIMLO(100),SP1MLO(100),SP2MLO(100) STAR0042
            DIMENSION IDELO(4,100),IMELO(4,100),IIELO(4,100),SP1ELO(4,100) STAR0043
            DIMENSION SP2E_O(4,100),IMMLH(100),IMMLO(100)                  STAR0044
            DIMENSION MIDE_H(4),IDMLH(100),IIMLH(100),SP1MLH(100),SP2MLH(100) STAR0045
            DIMENSION IDELH(4,100),IMELH(4,100),IIELH(4,100),SP1ELH(4,100) STAR0046
            DIMENSION SP2E_H(4,100),IDO(100),IDH(100),IDOE(4,100),IDHE(4,100) STAR0047
            DIMENSION SUMMO(20),SUMMH(20),PTBTMO(16),PTBTMH(16),PMAXO(16)  STAR0048
            DIMENSION PMAXH(16),SUMNO(20),SUMNH(20),PDESO(16),PDESH(16)    STAR0049
```

Fig. B-1 STAR Program Listing

```
      DIMENSION O2(2),H2(2),WELH(16,4),WELHT(16),WMLH(16),WLHT(16)      STAR0050
      DIMENSION              WELO(16,4),WELOT(16),WMLO(16),WLOT(16)      STAR0051
      DIMENSION ADO(16),ADH(16)                                          STAR0052
      DIMENSION ABC(5504)                                                STAR0053
      EQUIVALENCE (ABC,WELO),(ABC(65),WELOT),(ABC(81),WMLO),(ABC(97),WLOSTAR0054
     1T),(ABC(113),WELH),(ABC(177),WELHT),(ABC(193),WMLH),(ABC(209),WLHTSTAR0055
     2),(ABC(225),DLPACO),(ABC(545),DLPACH),(ABC(865),DLPLNO),(ABC(1185)STAR0056
     3,DLPLNH),(ABC(1505),PENNUO),(ABC(2065),PENNUH),(ABC(2625),PULLC), STAR0057
     4(ABC(2945),PULLH),(ABC(3265),PTKBTO),(ABC(3825),PTKBTH),(ABC(4385)STAR0058
     5,PULLRO),(ABC(4945),PULLRH)                                        STAR0059
C                                                                        STAR0060
      INTEGER SYSNUM                                                     STAR0061
      REAL NPSPO,NPSPH                                                   STAR0062
      REAL LOADO1,LOADH1,LOADO2,LOADH2                                   STAR0063
C                                                                        STAR0064
      COMMON/AAA/FIFRAC,TIMEA,WDTFRO,WDTFRH,NPSPO,NPSPH                  STAR0065
      COMMON/AAA/PPDGOT,PPDGHT,TLIQSC,TLIQSH,TSVAPO,TSVAPH               STAR0066
      COMMON/AAA/TOGOT,TOGHT                                             STAR0067
      COMMON/AAA/LOADO1,LOADH1,LOADO2,LOADH2                             STAR0068
      COMMON/BBB/NSIZE,SYSNUM,NOP,NOPI,IGOON,NPTS,MPTS                   STAR0069
      COMMON/CCC/GC,RHOOX,RHOHY,VWGTN                                    STAR0070
      COMMON/DDD/WDOTNO,WDOTNH,FROM,CPIPEL,HPIPEL,OPD,WPD,OKPD,HKPD,ST,  STAR0071
     1OXHTLN,HYHTLN,PENNNO,PENNNH,PENTCL,TENINO,TENINH                   STAR0072
      COMMON/EEE/OPDJM,ODDUM,HPDUM,HDDUM,VWGTCH,ODLDUM,OCAYP,ODTINC,     STAR0073
     1HOLDUM,HCAYP,HDTINC,TVAPO,TVAPH,PVAPC,PVPENO,PVAPH,PVPENH,PNCWGT   STAR0074
      COMMON/FFF/WDODTO,WDOTH,ZLPACC,ZLPACH,VWGTNO,FTOW,DIFWGT,DLPHDO,   STAR0075
     1DLPHDH,ZLPLNO,ZLPLNH,PENGO,PENGH,PCWGTC,PCWGTH                     STAR0076
      COMMON/FFF/PUVAPO,PSVAPO,PUVAPH,PSVAPH,PPVAPO,PPVAPH               STAR0077
      COMMON/FFF/ULVLIC,ULVLIH,HEADIC,HEADIH                             STAR0078
      COMMON/GGG/WTULGO,WTULGH,ULVO2,ULVH2,HEADO2,HEADH2                 STAR0079
      COMMON/GGG/ULVLO2,ULVLH2                                           STAR0080
C                                                                        STAR0081
      DATA FEET,GC/12.,32.172/                                           STAR0082
      DATA O2/'OXYGEN',' '/H2/'HYDROG','EN  '/                           STAR0083
      DATA RHOOX,RHOHY/70.9,4.396/                                       STAR0084
      DATA IIN,IOT,PI,PI2O3/5,6,3.1415927,2.0943951/                     STAR0085
C                                                                        STAR0086
      CALL MOVER(0.0,ABC,1.5504)                                         STAR0087
      ICASE=0                                                            STAR0088
C     ***********************************************************************STAR0089
C     READ IN THE INPUT DATA DECK                                        STAR0090
C                                                                        STAR0091
C           *** INPUT DATA DEFINITIONS ***                               STAR0092
C                                                                        STAR0093
C     ***********************************************************************STAR0094
C     ST     - ANALYSIS TITLE CARD - SPECIFIES ENGINE CONSIDERED         STAR0095
C     THIS CARD MUST BE SUPPLIED FOR EACH CASE                           STAR0096
C                                                                        STAR0097
   10 READ (5,15)(ST(I),I=1,7)                                           STAR0098
   15 FORMAT(7A6)                                                        STAR0099
      ICASE=ICASE+1                                                      STAR0100
C     ***********************************************************************STAR0101
      DO 20 K=1,16                                                       STAR0102
      IP(K)=0                                                            STAR0103
   20 CONTINUE                                                           STAR0104
C     ***********************************************************************STAR0105
C                                                                        STAR0106
C     INPUT DATA FLAGS                                                   STAR0107
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      C     THIS CARD MUST BE SUPPLIED FOR EACH CASE                          STAR0108
      C                                                                       STAR0109
            READ (5,25)(IP(K),K=1,16)                                         STAR0110
         25 FORMAT(1611)                                                      STAR0111
            IF (IP(1).LT.1) GO TO 35                                          STAR0112
      C     ****************************************************************STAR0113
      C                                                                       STAR0114
      C     NML     = NUMBER OF MAIN FEEDLINE SIZES TO BE CONSIDERED (UP TO 12)STAR0115
      C     NEL     = NUMBER OF ENGINE FEEDLINE ATTACHE) TO EACH MAIN LINE (UP STAR0116
      C     SYSNUM  = IF 1, PROGRAM COMPUTES FOR OXID, FEEDLINES ONLY,        STAR0117
      C             = IF 2, PROGRAM COMPUTES FOR FUEL  FEEDLINES ONLY,        STAR0118
      C             = IF 3, PROGRAM COMPUTES FOR BOTH  FEEDLINES,             STAR0119
      C     NSIZE   = TOTAL NUMBER OF FEEDLINES PER TANK = NEL*NML            STAR0120
      C                                                                       STAR0121
      C     NOP,    = NUMBER OF ENGINES FED BY A MAIN FEEDLINE                STAR0122
      C                                                                       STAR0123
      C     NOP1    = NUMBER OF ENGINES ON VEHICLE                            STAR0124
      C                                                                       STAR0125
      C     NPTS    = NUMBER OF TIME POINTS BEING CONSIDERED IN ANALYSIS(UP TO STAR0126
      C                                                                       STAR0127
      C     NGST    = GROUND START FLAG (NGST=2 FOR GROUND START)             STAR0128
      C     TOTMLO  =  TOTAL LENGTH OF MAIN OXYGEN FEEDLINE   FT              STAR0129
      C     TOTMLH  =  TOTAL LENGTH OF MAIN HYDROGEN FEEDLINE  FT             STAR0130
            READ (5,30)NEL,NML,SYSNUM,NOP,NOP1,NPTS,NGST                      STAR0131
         30 FORMAT((12I6))                                                    STAR0132
            READ (5,100)TOTMLO,TOTMLH                                         STAR0133
      C     ****************************************************************STAR0134
            NSIZE=NEL*NML                                                     STAR0135
            NELP=NEL+1                                                        STAR0136
      C                                                                       STAR0137
      C     ****************************************************************STAR0138
         35 IF (IP(2).LT.1) GO TO 40                                          STAR0139
      C     ****************************************************************STAR0140
      C                                                                       STAR0141
      C     EGLR1   = LENGTHS AND RADII OF TANK SECTIONS  ( 9 VALUES)         STAR0142
      C                                                                       STAR0143
            READ (5,100)EGLR1                                                 STAR0144
      C     ****************************************************************STAR0145
         40 IF (IP(3).LT.1) GO TO 65                                          STAR0146
      C     ****************************************************************STAR0147
      C                                                                       STAR0148
      C     MIDMLO = TOTAL NUMBER OF COMPONENTS IN MAIN OXYGEN FEEDLINE (UP TOSTAR0149
      C     MIDELO(NL)= TOTAL NUMBER OF COMPONENTS IN ENGINE OXYGEN           STAR0150
      C                 FEEDLINE NUMBER NL (UP TO 100)                      STAR0151
      C     IDMLO   = COMPONENT TYPE FLAG FOR MAIN OXYGEN LINE                STAR0152
      C     IMMLO   = COMPONENT MATERIAL FLAG FOR MAIN OYGEN LINE             STAR0153
      C     IIMLO   = COMPONENT INSULATION FLAG FOR MAIN OXYGEN LINE          STAR0154
      C     IMLO    = SUBSCRIPT DENOTING COMPONENT POSITION IN MAIN           STAR0155
      C               OXYGEN FEEDLINE (IMLO = 1 AT TANK BOTTOM)               STAR0156
      C     IELO(NL)=SUBSCRIPT DENOTING COMPONENT POSITION IN ENGINE          STAR0157
      C              OXYGEN FEEDLINE (IELO(NL) = MIDELO(NL) AT INLET TO ENGINESTAR0158
      C                                                                       STAR0159
      C     SP1MLO(I),SP2M_O(I),SP3MLO(I) = COMPONENT SPECIFICATIONS (SEE MANUSTAR0160
      C                                                                       STAR0161
      C     OPD(K),K=1,NEL = DIAMETERS OF OXYGEN ENGINE FEEDLINES (INCHES)    STAR0162
      C     OPD(K),K=NEL+1,NSIZE = CANDIDATE DIAMETERS OF MAIN OXYGEN FEEDLINESTAR0163
      C                                                                       STAR0164
            READ (5,30)MIDMLO,(MIDELO(NL),NL=1,NEL)                           STAR0165
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      DO 50 I=1,MIDM_O                                                  STAR0166
      READ (5,45)IDM_O(I),IMMLO(I),IIMLO(I),SP1MLO(I),SP2MLO(I),SP3MLO(ISTAR0167
     1)                                                                 STAR0168
      IF (IDMLO(I),LE,25) GO TO 50                                      STAR0169
      ITEMP=IDMLO(I)/10                                                 STAR0170
      IDO(I)=IDM_O(I)*ITEMP                                             STAR0171
      IDMLO(I)=ITEMP                                                    STAR0172
   45 FORMAT(3I6,3E12,8)                                                STAR0173
   50 CONTINUE                                                          STAR0174
      DO 60 NL=1,NEL                                                    STAR0175
      MID=MIDELO(NL)                                                    STAR0176
      DO 55 I=1,MID                                                     STAR0177
      READ (5,45)IDE_O(NL,I),IMELO(NL,I),IIELO(NL,I),SP1ELO(NL,I),SP2ELOSTAR0178
     1(NL,I),SP3ELO(NL,I)                                               STAR0179
      IF (IDELO(NL,I),LE,25) GO TO 55                                   STAR0180
      ITEMP=IDELO(NL,I)/10                                              STAR0181
      IDOE(NL,I)=IDE_O(NL,I)-ITEMP                                      STAR0182
      IDELO(NL,I)=ITEMP                                                 STAR0183
   55 CONTINUE                                                          STAR0184
   60 CONTINUE                                                          STAR0185
      READ (5,100)(DPD(K),K=1,NSIZE)                                    STAR0186
C                                                                       STAR0187
C     ******************************************************************STAR0188
   65 IF (IP(4),LT,1) GO TO 85                                          STAR0189
C     ******************************************************************STAR0190
C     REPEAT FOR HYDROGEN FEED SYSTEM                                   STAR0191
C                                                                       STAR0192
C     HPD(K) = DIAMETER FOR THE KTH FUEL FEED LINE          (INCHES)    STAR0193
      READ (5,30)MIDMLH,(MIDELH(NL),NL=1,NEL)                          STAR0194
      DO 70 I=1,MIDM_H                                                  STAR0195
      READ (5,45)IDM_H(I),IMMLH(I),IIMLH(I),SP1MLH(I),SP2MLH(I),SP3MLH(ISTAR0196
     1)                                                                 STAR0197
      IF (IDMLH(I),LE,25) GO TO 70                                      STAR0198
      ITEMP=IDMLH(I)/10                                                 STAR0199
      IDH(I)=IDM_H(I)*ITEMP                                             STAR0200
      IDMLH(I)=ITEMP                                                    STAR0201
   70 CONTINUE                                                          STAR0202
      DO 80 NL=1,NEL                                                    STAR0203
      MID=MIDELH(NL)                                                    STAR0204
      DO 75 I=1,MID                                                     STAR0205
      READ (5,45)IDE_H(NL,I),IMELH(NL,I),IIELH(NL,I),SP1ELH(NL,I),SP2ELHSTAR0206
     1(NL,I),SP3ELH(NL,I)                                               STAR0207
      IF (IDELH(NL,I),LE,25) GO TO 75                                   STAR0208
      ITEMP=IDELH(NL,I)                                                 STAR0209
      IDHE(NL,I)=IDE_H(NL,I)-ITEMP                                      STAR0210
      IDELH(NL,I)=ITEMP                                                 STAR0211
   75 CONTINUE                                                          STAR0212
   80 CONTINUE                                                          STAR0213
      READ (5,100)(HPD(K),K=1,NSIZE)                                    STAR0214
C     ******************************************************************STAR0215
   85 IF (IP(5),LT,1) GO TO 90                                          STAR0216
C     ******************************************************************STAR0217
C                                                                       STAR0218
C     OXHTLN = FEEDLINE HEAD HEIGHT ABOVE ENGINE INLET,OXID, (FT)       STAR0219
C     HYHTLN = FEEDLINE HEAD HEIGHT ABOVE ENGINE INLET,FUEL, (FT)       STAR0220
C     PDLO   = OXYGEN FEEDLINE DESIGN PRESSURE (OPTIONAL)    (PSI)      STAR0221
C     PDLH   = HYDROGEN FEEDLINE DESIGN PRESSURE (OPTIONAL)  (PSI)      STAR0222
C                                                                       STAR0223
```

Fig. B-1 STAR Program Listing (Cont'd)

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224.    C     NOTE: A FACTOR OF SAFETY OF 2.5 IS APPLIED BY THE                    STAR0224
225.    C           PROGRAM TO THE ABOVE PRESSURES IN THE COMPUTATION              STAR0225
226.    C           OF LINE WALL THICKNESSES, IF (PDLO,PDLH).LE.0, PROGRAM         STAR0226
227.    C           USES MAXIMUM TANK BOTTOM PRESSURE OR ENGINE INLET PRESSURE.    STAR0227
228.    C                                                                          STAR0228
229.          READ (5,100)OXHTLN,HYHTLN,PDLO,PDLH                                  STAR0229
230.    C                                                                          STAR0230
231.    C     ***********************************************************************STAR0231
232.       90 IF (IP(6),LT,1) GO TO 95                                             STAR0232
233.    C     ***********************************************************************STAR0233
234.    C                                                                          STAR0234
235.    C     LOADO1 = LOADED WEIGHT OF OXIDIZER                    LBS          STAR0235
236.    C     LOADH1 = LOADED WEIGHT OF FUEL                        LBS          STAR0236
237.    C                                                                          STAR0237
238.    C     VWGTN = TOTAL VEHICLE WEIGHT AT IGNITION              LBS          STAR0238
239.          READ (5,100)LOADO1,LOADH1,VWGTN                                      STAR0239
240.    C                                                                          STAR0240
241.    C     ***********************************************************************STAR0241
242.       95 IF (IP(7),LT,1) GO TO 105                                            STAR0242
243.    C     ***********************************************************************STAR0243
244.    C                                                                          STAR0244
245.    C     WDOTNO = OXIDIZER NOMINAL FLOW RATE FOR SINGLE ENGINE  (LBS/SEC)     STAR0245
246.    C     WDOTNH = FUEL NOMINAL FLOW RATE FOR SINGLE ENGINE      (LBS/SEC)     STAR0246
247.    C     FNOM   = NOMINAL THRUST FOR SINGLE ENGINE              (LBS)         STAR0247
248.    C                                                                          STAR0248
249.          READ (5,100)WDOTNO,WDOTNH,FNOM                                       STAR0249
250.      100 FORMAT((6E12,8))                                                     STAR0250
251.    C                                                                          STAR0251
252.    C     ***********************************************************************STAR0252
253.      105 IF (IP(8),LT,1) GO TO 110                                            STAR0253
254.    C     ***********************************************************************STAR0254
255.    C                                                                          STAR0255
256.    C     TENINO = TEMP, OF OXID, FLUID AT ENGINE INLET          (DEG,R)     STAR0256
257.    C     TENINH = TEMP, OF FUEL  FLUID AT ENGINE INLET          (DEG,R)     STAR0257
258.    C     TLIQSO = TEMP, OF OXID, FLUID SURFACE IN TANK          DEG, R      STAR0258
259.    C     TLIQSH = TEMP, OF FUEL FLUID SURFACE IN TANK           DEG,R       STAR0259
260.    C     PENTOL = ENGINE INLET FLUID PRESSURE TOLERANCE         (PSI)       STAR0260
261.    C                                                                          STAR0261
262.          READ (5,100)TENINO,TENINH,TLIQSO,TLIQSH,PENTOL                       STAR0262
263.    C                                                                          STAR0263
264.    C     ***********************************************************************STAR0264
265.      110 IF (IP(9),LT,1) GO TO 115                                            STAR0265
266.    C     ***********************************************************************STAR0266
267.    C                                                                          STAR0267
268.    C     TIMEA  = TIME VALUES OF EVENTS IN TRANSIENT                          STAR0268
269.    C                                                                          STAR0269
270.          READ (5,100)(TIMEA(I),I=1,NPTS)                                      STAR0270
271.    C     ***********************************************************************STAR0271
272.      115 IF (IP(10),LT,1) GO TO 125                                           STAR0272
273.    C     ***********************************************************************STAR0273
274.    C                                                                          STAR0274
275.    C     WDTFRO = FRACTION OF OXIDIZER FLOW RATE AT TIMEA(I)                  STAR0275
276.    C     WDTFRH = FRACTION OF FUEL FLOW RATE AT TIMEA(I)                      STAR0276
277.    C                                                                          STAR0277
278.          READ (5,100)(WDTFRO(I),I=1,NPTS)                                     STAR0278
279.          IF (SYSNUM,EQ,1) GO TO 120                                           STAR0279
280.          READ (5,100)(WDTFRH(I),I=1,NPTS)                                     STAR0280
281.      120 CONTINUE                                                             STAR0281
```

Fig. B-1 STAR Program Listing (Cont'd)

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C     ********************************************************************STAR0292
  125 IF (IP(11).LT.1) GO TO 130                                            STAR0293
C     ********************************************************************STAR0294
C                                                                           STAR0295
C     FIFRAC = FRACTION OF NOMINAL THRUST AT TIMEA                          STAR0296
C                                                                           STAR0297
      READ (5,100)(FIFRAC(I),I=1,NPTS)                                      STAR0298
C     ********************************************************************STAR0299
  130 IF (IP(12).LT.1) GO TO 140                                            STAR0300
C     ********************************************************************STAR0301
C                                                                           STAR0302
C     NPSPO  = NET POSITIVE SUCTION PRESSURE FOR OXIDIZER     PSI           STAR0303
C     NPSPH  = NET POSITIVE SUCTION PRESSURE FOR FUEL         PSI           STAR0304
C                                                                           STAR0305
      READ (5,100)(NPSPO(N),N=1,NPTS)                                       STAR0306
      IF (SYSNUM.EQ.1) GO TO 135                                            STAR0307
      READ (5,100)(NPSPH(N),N=1,NPTS)                                       STAR0308
  135 CONTINUE                                                              STAR0309
C     ********************************************************************STAR0310
  140 IF (IP(13).LT.1) GO TO 150                                            STAR0311
C     ********************************************************************STAR0312
C                                                                           STAR0313
C     PENMNO = MINIMUM ENGINE INLET OXID.PRESSURE VALUE AT TIMEA            STAR0314
C     PENMNH = MINIMUM ENGINE INLET FUEL RESSURE VALUE AT TIMEA             STAR0315
C                                                                           STAR0316
      READ (5,100)(PENMNO(N),N=1,NPTS)                                      STAR0317
      IF (SYSNUM.EQ.1) GO TO 145                                            STAR0318
      READ (5,100)(PENMNH(N),N=1,NPTS)                                      STAR0319
  145 CONTINUE                                                              STAR0320
C     ********************************************************************STAR0321
  150 IF (IP(14).LT.1) GO TO 160                                            STAR0322
C     ********************************************************************STAR0323
C                                                                           STAR0324
C     PPDGOT = PART.PRESS. OF PRESSURANT GAS IN OXID. TANK    PSI           STAR0325
C     PPDGHT = PART.PRESS. OF PRESSURANT GAS IN FUEL  TANK    PSI           STAR0326
C                                                                           STAR0327
      READ (5,100)(PPDGOT(N),N=1,NPTS)                                      STAR0328
      IF (SYSNUM.EQ.1) GO TO 155                                            STAR0329
      READ (5,100)(PPDGHT(N),N=1,NPTS)                                      STAR0330
  155 CONTINUE                                                              STAR0331
C     ********************************************************************STAR0332
  160 IF (IP(15).LT.1) GO TO 170                                            STAR0333
C     ********************************************************************STAR0334
C                                                                           STAR0335
C     TDGOT  = TEMP. OF PRESSURANT GAS, IF NONE-SET EQUAL TO TLIQSO + 5.    STAR0336
C     TDGHT  = TEMP. OF PRESSURANT GAS, IF NONE-SET EQUAL TO TLIQSH + 5.    STAR0337
C                                                                           STAR0338
      READ (5,100)(TDGOT(N),N=1,NPTS)                                       STAR0339
      IF (SYSNUM.EQ.1) GO TO 165                                            STAR0340
      READ (5,100)(TDGHT(N),N=1,NPTS)                                       STAR0341
  165 CONTINUE                                                              STAR0342
C     ********************************************************************STAR0343
  170 IF (IP(16).LT.1) GO TO 175                                            STAR0344
C     ********************************************************************STAR0345
C                                                                           STAR0346
C     IGOON  = INDEX FOR ADDITIONAL CASES, IF IGOON = 1 THERE ARE MORE,     STAR0347
C              IF IGOON = 0, NO MORE.                                       STAR0348
C                                                                           STAR0349
```

Fig. B-1 STAR Program Listing (Cont'd)

```
340,          READ (5,30)IGOON                                                  STAR0340
341,       175 CONTINUE                                                         STAR0341
342,    C      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *STAR0342
343,    C                                                                       STAR0343
344,          LOADO2 = LOADO1/RHOOX                                             STAR0344
345,          LOADH2 = LOADH1/RHOHY                                             STAR0345
346,    C                                                                       STAR0346
347,    C     CALCULATE SLOPE OF FLOW RATE CURVE INCREMENTS                     STAR0347
348,    C                                                                       STAR0348
349,          MPTS = NPTS - 1                                                   STAR0349
350,          DO 180 J=1,MPTS                                                   STAR0350
351,          WDDOTO(J)=(WDTERO(J+1)-WDTERO(J))*WDOTNO/(TIMEA(J+1)-TIMEA(J))    STAR0351
352,          WDDOTH(J)=(WDTERH(J+1)-WDTERH(J))*WDOTNH/(TIMEA(J+1)-TIMEA(J))    STAR0352
353,       180 CONTINUE                                                         STAR0353
354,    C                                                                       STAR0354
355,    C     COMPUTE TOTAL LENGTHS OF FEEDLINES (ASSUME COMPONENT L/D = 1.0)   STAR0355
356,    C                                                                       STAR0356
357,          IF (SYSNUM.EQ.2) GO TO 210                                        STAR0357
358,    C                                                                       STAR0358
359,    C     OXYGEN FEEDLINE LENGTHS                                           STAR0359
360,    C                                                                       STAR0360
361,          DO 200 NL=1,NSIZE                                                 STAR0361
362,          SUM=0.                                                            STAR0362
363,          IF(NL.LE.NEL) MID=MIDELO(NL)                                      STAR0363
364,          IF(NL.GT.NEL) MID=MIDMLO                                          STAR0364
365,          DO 195 I=1,MID                                                    STAR0365
366,          IF(NL.LE.NEL) ID=IDELO(NL,I)                                      STAR0366
367,          IF(NL.GT.NEL) ID=IDMLO(I)                                         STAR0367
368,          IF (ID.GT.1) GO TO 185                                            STAR0368
369,          SUM=SUM+0.7854*OPD(NL)**2*0.083333                                STAR0369
370,          GO TO 195                                                         STAR0370
371,       185 IF (ID.EQ.9) GO TO 195                                           STAR0371
372,          IF (ID.GT.10) GO TO 190                                           STAR0372
373,          IF(NL.LE.NEL) SPEC=SP1ELO(NL,I)                                   STAR0373
374,          IF(NL.GT.NEL) SPEC=SP1MLO(I)                                      STAR0374
375,          SUM=SUM+SPEC                                                      STAR0375
376,          GO TO 195                                                         STAR0376
377,       190 SUM=SUM+OPD(NL)**2*0.083333                                      STAR0377
378,       195 CONTINUE                                                         STAR0378
379,          OPIPEL(NL)=SUM                                                    STAR0379
380,       200 CONTINUE                                                         STAR0380
381,    C     COMPUTE LENGTH RATIOS FOR STRAIGHT SECTIONS                       STAR0381
382,          DO 205 NL=NELP,NSIZE                                              STAR0382
383,          ADO(NL)=OPIPEL(NL)/TOTMLO                                         STAR0383
384,       205 CONTINUE                                                         STAR0384
385,          IF (SYSNUM.EQ.1) GO TO 240                                        STAR0385
386,    C                                                                       STAR0386
387,    C     HYDROGEN FEEDLINE LENGTHS                                         STAR0387
388,    C                                                                       STAR0388
389,       210 DO 230 NL=1,NSIZE                                                STAR0389
390,          SUM=0.                                                            STAR0390
391,          IF(NL.LE.NEL) MID=MIDELH(NL)                                      STAR0391
392,          IF(NL.GT.NEL) MID=MIDMLH                                          STAR0392
393,          DO 225 I=1,MID                                                    STAR0393
394,          IF(NL.LE.NEL) ID=IDELH(NL,I)                                      STAR0394
395,          IF(NL.GT.NEL) ID=IDMLH(I)                                         STAR0395
396,          IF (ID.GT.1) GO TO 215                                            STAR0396
397,          SUM=SUM+0.7854*HPD(NL)**2*0.083333                                STAR0397
```

Fig. B-1 STAR Program Listing (Cont'd)

```
398,          GO TO 225                                                    STAR0398
399,      215 IF (ID.EQ.9) GO TO 225                                       STAR0399
400,          IF (ID.GT.10) GO TO 220                                      STAR0400
401,          IF(NL.LE.NEL) SPEC=SP1ELH(NL,I)                              STAR0401
402,          IF(NL.GT.NEL) SPEC=SP1MLH(I)                                 STAR0402
403,          SUM=SUM+SPEC                                                 STAR0403
404,          GO TO 225                                                    STAR0404
405,      220 SUM=SUM+HPD(NL)*0.083333                                     STAR0405
406,      225 CONTINUE                                                     STAR0406
407,          HPIPEL(NL)=SUM                                               STAR0407
408,      230 CONTINUE                                                     STAR0408
409,  C       COMPUTE LENGTH RATIOS FOR STRAIGHT SECTIONS                  STAR0409
410,          DO 235 NL=NELP,NSIZE                                         STAR0410
411,          ADH(NL)=HPIPEL(NL)/TOTMLH                                    STAR0411
412,      235 CONTINUE                                                     STAR0412
413,  C                                                                    STAR0413
414,  C       CALCULATE PRESSURE DIFFERENCE TO SUPPLY ACCELERATION HEADS    STAR0414
415,  C                                                                    STAR0415
416,      240 DO 295 I=1,NSIZE                                             STAR0416
417,          GO TO (245,270,245),SYSNUM                                   STAR0417
418,      245 OPDUM = OPIPEL(I)                                            STAR0418
419,          ODDUM = OPD(I)**2                                            STAR0419
420,          IF (I.GT.NEL) GO TO 255                                      STAR0420
421,  C                                                                    STAR0421
422,  C       COMPUTE ACCELERATION HEAD IN SINGLE ENGINE OX FEED SECTION    STAR0422
423,  C                                                                    STAR0423
424,          DO 250 J=1,MPTS                                              STAR0424
425,          DLPACO(I,J)=(4.0*WDDOTO(J)*OPDUM*1.0)/(GC*PI*ODDUM)          STAR0425
426,      250 CONTINUE                                                     STAR0426
427,          GO TO 265                                                    STAR0427
428,  C                                                                    STAR0428
429,  C       COMPUTE ACCELERATION HEAD IN MAIN OX FEED SECTION             STAR0429
430,  C                                                                    STAR0430
431,      255 OPDUM=TOTMLO                                                 STAR0431
432,          DO 260 J=1,MPTS                                              STAR0432
433,          DLPACO(I,J)=(4.0*WDDOTO(J)*OPDUM*NOP)/(GC*PI*ODDUM)          STAR0433
434,      260 CONTINUE                                                     STAR0434
435,      265 CONTINUE                                                     STAR0435
436,          IF (SYSNUM.EQ.1) GO TO 295                                   STAR0436
437,      270 HPDUM = HPIPEL(I)                                            STAR0437
438,          HDDUM = HPD(I)**2                                            STAR0438
439,          IF (I.GT.NEL) GO TO 280                                      STAR0439
440,  C                                                                    STAR0440
441,  C       COMPUTE ACCELERATION HEAD IN SINGLE ENGINE FUEL FEED SECTION  STAR0441
442,  C                                                                    STAR0442
443,          DO 275 J=1,MPTS                                              STAR0443
444,          DLPACH(I,J)=(4.0*WDDOTH(J)*HPDUM*1.0)/(GC*PI*HDDUM)          STAR0444
445,      275 CONTINUE                                                     STAR0445
446,          GO TO 290                                                    STAR0446
447,  C                                                                    STAR0447
448,  C       COMPUTE ACCELERATION HEAD IN MAIN FUEL FEED SECTION           STAR0448
449,  C                                                                    STAR0449
450,      280 HPDUM=TOTMLH                                                 STAR0450
451,          DO 285 J=1,MPTS                                              STAR0451
452,          DLPACH(I,J)=(4.0*WDDOTH(J)*HPDUM*NOP)/(GC*PI*HDDUM)          STAR0452
453,      285 CONTINUE                                                     STAR0453
454,      290 CONTINUE                                                     STAR0454
455,      295 CONTINUE                                                     STAR0455
```

Fig. B-1 STAR Program Listing (Cont'd)

```
456.   C                                                                    STAR0456
457.   C     COMPUTE THE INITIAL ULLAGE VOLUMES AND HEAD HEIGHTS FOR TANKS  STAR0457
458.   C                                                                    STAR0458
459.         DO 300 I=1,9                                                   STAR0459
460.     300 EQLR(I)=EQ_R1(I)/FEET                                          STAR0460
461.         CALL INIVOL                                                    STAR0461
462.   C                                                                    STAR0462
463.         CALL ULLHED(LOADO2,LOADH2)                                     STAR0463
464.         ULVL1O = UVLO2                                                 STAR0464
465.         ULVL1H = UVLH2                                                 STAR0465
466.         HEAD1O = HDO2                                                  STAR0466
467.         HEAD1H = HDH2                                                  STAR0467
468.   C                                                                    STAR0468
469.   C     COMPUTE VEHICLE WEIGHT CHANGE FOR NOP1 ENGINE OPERATION        STAR0469
470.   C                                                                    STAR0470
471.         VWGTCH = VWGTN                                                 STAR0471
472.         PNCWGT = 0.0                                                   STAR0472
473.         VLO2 = 0.0                                                     STAR0473
474.         VLH2 = 0.0                                                     STAR0474
475.         DO 310 J=1,MPTS                                                STAR0475
476.         DFWGTO(J)=((WDTFRO(J+1)+ WDTFRC(J))/2.0)*WJOTNO                STAR0476
477.         DFWGTH(J)=((WDTFRH(J+1)+ WDTFRH(J))/2.0)*WJOTNH                STAR0477
478.         DIFWGT(J)=DFWGTO(J)+DFWGTH(J)                                  STAR0478
479.         DELTIM = (TIMEA(J+1)-TIMEA(J))                                 STAR0479
480.         VWGTCH = VWGTCH - (DIFWGT(J)*NOP1*DELTIM)                      STAR0480
481.         VWGTNU(J) =VWGTCH                                              STAR0481
482.         PCWGTO(J) = DFWGTO(J)*NOP1*DELTIM                              STAR0482
483.         PCWGTH(J) = DFWGTH(J)*NOP1*DELTIM                              STAR0483
484.         PNCWGT = PNCWGT + (DIFWGT(J)*NOP1*DELTIM)                      STAR0484
485.         PROWGT(J) = PNCWGT                                             STAR0485
486.   C                                                                    STAR0486
487.   C     CALCULATE THRUST TO WGT RATIO AS F(T)                          STAR0487
488.   C                                                                    STAR0488
489.         FTOW(J) = (FIFRAC(J)*FNOM*NOP1)/VWGTNU(J)                      STAR0489
490.         IF (FTOW(J).GT.1.) GO TO 305                                   STAR0490
491.         IF(NGST.GT.1) FTOW(J)=1.                                       STAR0491
492.   C                                                                    STAR0492
493.   C     CALCULATE HEAD HEIGHT IN PROPELLANT TANKS FOR OXID. AND FUEL   STAR0493
494.   C                                                                    STAR0494
495.     305 VLO2 = VLO2+((DFWGTO(J)*NOP1*(TIMEA(J+1)-TIMEA(J)))/RHOOX)    STAR0495
496.         VLGO2(J)=VLO2                                                  STAR0496
497.         VRMO2 = LOADO2 - VLO2                                          STAR0497
498.         VLH2 = VLH2+((DFWGTH(J)*NOP1*(TIMEA(J+1)-TIMEA(J)))/RHOHY)    STAR0498
499.         VLGH2(J)=VLH2                                                  STAR0499
500.         VRMH2 = LOADH2 - VLH2                                          STAR0500
501.         CALL ULLHED(VRMO2,VRMH2)                                       STAR0501
502.         ULVLO2(J)= UVLO2                                               STAR0502
503.         ULVLH2(J)= UVLH2                                               STAR0503
504.         HEADO2(J)= HDO2                                                STAR0504
505.         HEADH2(J)= HDH2                                                STAR0505
506.   C                                                                    STAR0506
507.   C     CALCULATE PRESSURE DIFFERENCE DUE TO TOTAL HEAD AS F(T)        STAR0507
508.   C                                                                    STAR0508
509.         DLPHDO(J)=(FTOW(J) * RHOOX * (HDO2+OXHTLN))/144.0              STAR0509
510.         DLPHDH(J)=(FTOW(J) * RHOHY * (HDH2+HYHTLN))/144.0              STAR0510
511.     310 CONTINUE                                                       STAR0511
512.   C                                                                    STAR0512
513.   C     CALCULATE LINE PRESSURE DROP                                   STAR0513
```

Fig. B-1 STAR Program Listing (Cont'd)

```
514,   C                                                                STAR0514
515,         DO 385 I=1,NSIZE                                           STAR0515
516,         GO TO (315,350,315),SYSNUM                                 STAR0516
517,     315 ODLDUM = OPD(I)**4                                         STAR0517
518,         OCAYP=0,                                                   STAR0518
519,         D=OPD(I)                                                   STAR0519
520,         CONGP = 3,62806                                            STAR0520
521,         IF (I,GT,NEL) GO TO 330                                    STAR0521
522,   C                                                                STAR0522
523,   C     COMPUTE LINE PRESSURE DROP IN SINGLE ENGINE OX FEED SECTION STAR0523
524,   C                                                                STAR0524
525,         MID=MIDELO(I)                                              STAR0525
526,         DO 320 NID=1,MID                                           STAR0526
527,         ID=IDELO( I,NID)                                           STAR0527
528,         SP1=SP1ELO( I,NID)                                         STAR0528
529,         SP2=SP2ELO( I,NID)                                         STAR0529
530,         CALL FLORES(ID,D,SP1,SP2,RES)                              STAR0530
531,         OCAYP=OCAYP+RES                                            STAR0531
532,     320 CONTINUE                                                   STAR0532
533,         OCAYP=0,144*OPIPEL(I)/D*OCAYP                              STAR0533
534,         OKPD(I)=OCAYP                                              STAR0534
535,         DO 325 J=1,MPTS                                            STAR0535
536,         DLPLNO(I,J)=(CONGP*OCAYP*(DFWGTO(J)**2)*1,0)/(RHOOX*ODLDUM) STAR0536
537,     325 CONTINUE                                                   STAR0537
538,         GO TO 345                                                  STAR0538
539,   C                                                                STAR0539
540,   C     COMPUTE LINE PRESSURE DROP IN MAIN OX FEED LINE SECTION     STAR0540
541,   C                                                                STAR0541
542,     330 DO 335 NID=1,MIDMLO                                        STAR0542
543,         ID=IDMLO(NID)                                              STAR0543
544,         SP1=SP1MLO(NID)                                            STAR0544
545,         SP2=SP2MLO(NID)                                            STAR0545
546,         CALL FLORES(ID,D,SP1,SP2,RES)                              STAR0546
547,         OCAYP=OCAYP+RES                                            STAR0547
548,     335 CONTINUE                                                   STAR0548
549,         OCAYP=0,144*TOTMLO/D*OCAYP                                 STAR0549
550,         OKPD(I)=OCAYP                                              STAR0550
551,         DO 340 J=1,MPTS                                            STAR0551
552,         DLPLNO(I,J)=(CONGP*OCAYP*((NOP*DFWGTO(J))**2))/(RHOOX*ODLDUM) STAR0552
553,     340 CONTINUE                                                   STAR0553
554,     345 CONTINUE                                                   STAR0554
555,         IF (SYSNUM,EQ,1) GO TO 385                                 STAR0555
556,     350 HDLDUM = HPD(I)**4                                         STAR0556
557,         HCAYP=0,                                                   STAR0557
558,         D=HPD(I)                                                   STAR0558
559,         CONGP = 3,62806                                            STAR0559
560,         IF (I,GT,NEL) GO TO 365                                    STAR0560
561,   C                                                                STAR0561
562,   C     COMPUTE LINE PRESSURE DROP IN SINGLE ENGINE FUEL FEED SECTION STAR0562
563,   C                                                                STAR0563
564,         MID=MIDELH(I)                                              STAR0564
565,         DO 355 NID=1,MID                                           STAR0565
566,         ID=IDELH( I,NID)                                           STAR0566
567,         SP1=SP1ELH( I,NID)                                         STAR0567
568,         SP2=SP2ELH( I,NID)                                         STAR0568
569,         CALL FLORES(ID,D,SP1,SP2,RES)                              STAR0569
570,         HCAYP=HCAYP+RES                                            STAR0570
571,     355 CONTINUE                                                   STAR0571
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      HCAYP=0.144*HPIPEL(I)/D*HCAYP                                    STAR0572
      HKPD(I)=HCAYP                                                    STAR0573
      DO 360 J=1,MPTS                                                  STAR0574
      DLPLNH(I,J)=(CONGP*HCAYP*(DFWGTH(J)**2)*1.J)/(RHOHY*HDLDUM)      STAR0575
  360 CONTINUE                                                         STAR0576
      GO TO 380                                                        STAR0577
C                                                                      STAR0578
C     COMPUTE LINE PRESSURE DROP IN MAIN FUEL FEED LINE SECTION        STAR0579
C                                                                      STAR0580
  365 DO 370 NID=1,MIDMLH                                              STAR0581
      ID=IDMLH(NID)                                                    STAR0582
      SP1=SP1MLH(NID)                                                  STAR0583
      SP2=SP2MLH(NID)                                                  STAR0584
      CALL FLORES(ID,D,SP1,SP2,RES)                                    STAR0585
      HCAYP=HCAYP+RES                                                  STAR0586
  370 CONTINUE                                                         STAR0587
      HCAYP=0.144*TOTMLH/D*HCAYP                                       STAR0588
      HKPD(I)=HCAYP                                                    STAR0589
      DO 375 J=1,MPTS                                                  STAR0590
      DLPLNH(I,J)=(CONGP*HCAYP*((NOP*DFWGTH(J))**2))/(RHOHY*HDLDUM)    STAR0591
  375 CONTINUE                                                         STAR0592
  380 CONTINUE                                                         STAR0593
  385 CONTINUE                                                         STAR0594
C                                                                      STAR0595
C     CALCULATE  ULLAGE PRESSURE REQUIRED                              STAR0596
C                                                                      STAR0597
      TVAPO = TENINO                                                   STAR0598
      CALL PVAPOR(TVAPO,1,PVAPO)                                       STAR0599
      PVPENO = PVAPO                                                   STAR0600
      TVAPH = TENINH                                                   STAR0601
      CALL PVAPOR(TVAPH,2,PVAPH)                                       STAR0602
      PVPENH = PVAPH                                                   STAR0603
      DO 400 J=1,MPTS                                                  STAR0604
      GO TO (390,395,390),SYSNUM                                       STAR0605
  390 PENGO(J)=PVPENO + NPSPO(J)                                       STAR0606
      IF(PENGO(J),LT.PENMNO(J)) PENGO(J)= PENMNO(J)                    STAR0607
      IF (SYSNUM.EQ.1) GO TO 400                                       STAR0608
  395 PENGH(J)=PVPENH + NPSPH(J)                                       STAR0609
      IF(PENGH(J),LT.PENMNH(J)) PENGH(J)= PENMNH(J)                    STAR0610
  400 CONTINUE                                                         STAR0611
      DO 425 I=NELP,NSIZE                                              STAR0612
      DO 420 J=1,MPTS                                                  STAR0613
      SUMO=0.                                                          STAR0614
      SUMH=0.                                                          STAR0615
      SUMMO(J)=0.                                                      STAR0616
      SUMMH(J)=0.                                                      STAR0617
      DO 405 N=1,NEL                                                   STAR0618
      SUMO=DLPLNO(N,J)+DLPACO(N,J)                                     STAR0619
      SUMH=DLPLNH(N,J)+DLPACH(N,J)                                     STAR0620
      IF(SUMO,GT,SUMMO(J)) SUMMO(J)=SUMO                               STAR0621
      IF(SUMH,GT,SUMMH(J)) SUMMH(J)=SUMH                               STAR0622
  405 CONTINUE                                                         STAR0623
      GO TO (410,415,410),SYSNUM                                       STAR0624
  410 PULLO(I,J)=PENGO(J)+DLPLNO(I,J)+DLPACO(I,J)                      STAR0625
     1           -DLPHDO(J)+SUMMO(J)+PENTOL                            STAR0626
      IF (SYSNUM.EQ.1) GO TO 420                                       STAR0627
  415 PULLH(I,J)=PENGH(J)+DLPLNH(I,J)+DLPACH(I,J)                      STAR0628
     1           -DLPHDH(J)+SUMMH(J)+PENTOL                            STAR0629
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      420 CONTINUE                                                          STAR0630
      425 CONTINUE                                                          STAR0631
C                                                                           STAR0632
C     CALCULATE MINIMUM ULLAGE PRESSURE REQUIRED                            STAR0633
C                                                                           STAR0634
      TSVAPO = TLIQSO                                                       STAR0635
      CALL PVAPOR(TSVAPO,1,PSVAPO)                                          STAR0636
      PUVAPO = PSVAPO                                                       STAR0637
      TSVAPH = TLIQSH                                                       STAR0638
      CALL PVAPOR(TSVAPH,2,PSVAPH)                                          STAR0639
      PUVAPH = PSVAPH                                                       STAR0640
C                                                                           STAR0641
      DO 445 I=NELP,NSIZE                                                   STAR0642
      DO 440 J=1,MPTS                                                       STAR0643
      GO TO (430,435,430),SYSNUM                                            STAR0644
  430 PULMNO(J) = PUVAPO + PPDGOT(J)                                        STAR0645
      IF(PULLO(I,J).GT.PULMNO(J)) PULLRO(I,J) = PULLO(I,J)                  STAR0646
      IF(PULLO(I,J).LE.PULMNO(J)) PULLRO(I,J)=PULMNO(J)                     STAR0647
      IF (SYSNUM.EQ.1) GO TO 440                                            STAR0648
  435 PULMNH(J) = PUVAPH + PPDGHT(J)                                        STAR0649
      IF(PULLH(I,J).GT.PULMNH(J)) PULLRH(I,J) = PULLH(I,J)                  STAR0650
      IF(PULLH(I,J).LE.PULMNH(J)) PULLRH(I,J)=PULMNH(J)                     STAR0651
  440 CONTINUE                                                              STAR0652
  445 CONTINUE                                                              STAR0653
C                                                                           STAR0654
C     CALCULATE  PRESSURE AT TANK BOTTOM (OXID, AND FUEL)                   STAR0655
C                                                                           STAR0656
      DO 465 I=NELP,NSIZE                                                   STAR0657
      PTBTMO(I)=0.                                                          STAR0658
      PTBTMH(I)=0.                                                          STAR0659
      DO 460 J=1,MPTS                                                       STAR0660
      GO TO (450,455,450),SYSNUM                                            STAR0661
  450 PTKBTO(I,J) = PULLRO(I,J) + ((RHOOX * FTOW(J) * HEADO2(J))/144.0)     STAR0662
      IF (SYSNUM.EQ.1) GO TO 460                                            STAR0663
  455 PTKBTH(I,J) = PULLRH(I,J) + ((RHOHY * FTOW(J) * HEADH2(J))/144.0)     STAR0664
      IF(PTKBTO(I,J).GT.PTBTMO(I)) PTBTMO(I)=PTKBTO(I,J)                    STAR0665
      IF(PTKBTH(I,J).GT.PTBTMH(I)) PTBTMH(I)=PTKBTH(I,J)                    STAR0666
  460 CONTINUE                                                              STAR0667
  465 CONTINUE                                                              STAR0668
C                                                                           STAR0669
C     CALCULATE WEIGHT OF ULLAGE GAS                                        STAR0670
C                                                                           STAR0671
      DO 485 J=1,MPTS                                                       STAR0672
      GO TO (470,475,470),SYSNUM                                            STAR0673
  470 TMPULO=((TLIQSO + TDGOT(J))/2.0)                                      STAR0674
      I=NELP                                                                STAR0675
      CALL ZFIND(TMPULO,PULLRO(I,J),1,Z)                                    STAR0676
      ROX = FINDR(1)                                                        STAR0677
      RHOLOG=144.0*PULLRO(I,J)/(Z*ROX*TMPULO)                               STAR0678
      WTULGO(J)=RHOLOG*ULVLO2(J)                                            STAR0679
      IF (SYSNUM.EQ.1) GO TO 480                                            STAR0680
  475 TMPULH=((TLIQSH + TDGHT(J))/2.0)                                      STAR0681
      RHOLHG = PTDENS(PULLRH(I,J),TMPULH)                                   STAR0682
      WTULGH(J)=RHOLHG*ULVLH2(J)                                            STAR0683
  480 CONTINUE                                                              STAR0684
  485 CONTINUE                                                              STAR0685
C                                                                           STAR0686
C     CALCULATE LINE HEAD PRESSURE                                          STAR0687
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      C                                                                 STAR0688
            DO 500 J=1,MPTS                                             STAR0689
            GO TO (490,495,490),SYSNUM                                  STAR0690
        490 PHDLNO(J)=((RHOOX*FTOW(J)*OXHTLN)/144.0)                    STAR0691
            IF (SYSNUM.EQ.1) GO TO 500                                  STAR0692
        495 PHDLNH(J)=((RHOHY*FTOW(J)*HYHTLN)/144.0)                    STAR0693
        500 CONTINUE                                                    STAR0694
      C                                                                 STAR0695
      C     RECOMPUTE PRESSURE AT THE ENGINE                            STAR0696
      C                                                                 STAR0697
            DO 520 I=NELP,NSIZE                                         STAR0698
            DO 515 J=1,MPTS                                             STAR0699
            GO TO (505,510,505),SYSNUM                                  STAR0700
        505 PENNUO(I,J)=PT(BTO(I,J)+PHDLNO(J)-DLPACO(I,J)               STAR0701
           1            -D_PLNO(I,J)-SUMMO(J)                           STAR0702
            IF (SYSNUM.EQ.1) GO TO 515                                  STAR0703
        510 PENNUH(I,J)=PT(BTH(I,J)+PHDLNH(J)-DLPACH(I,J)               STAR0704
           1            -DLPLNH(I,J)-SUMMH(J)                           STAR0705
        515 CONTINUE                                                    STAR0706
        520 CONTINUE                                                    STAR0707
      C                                                                 STAR0708
      C     COMPUTE MAXIMUM VALUE OF ENGINE INLET PRESSURE AS A FUNCTION OF TISTAR0709
      C                                                                 STAR0710
            DO 570 I=NELP,NSIZE                                         STAR0711
            PMAXO(I)=0.                                                 STAR0712
            PMAXH(I)=0.                                                 STAR0713
            DO 530 J=1,MPTS                                             STAR0714
      C                                                                 STAR0715
      C     COMPUTE MINIMUM ENGINE LINE PRESSURE DROP AT THIS TIME      STAR0716
      C                                                                 STAR0717
            SUMNO(J)=1.E+10                                             STAR0718
            SUMNH(J)=1.E+10                                             STAR0719
            DO 525 N=1,NEL                                              STAR0720
            SUMO=DLPLNO(N,J)+DLPACO(N,J)                                STAR0721
            SUMH=DLPLNH(N,J)+DLPACH(N,J)                                STAR0722
            IF(SUMO.LT.SUMNO(J)) SUMNO(J)=SUMO                          STAR0723
            IF(SUMH.LT.SUMNH(J)) SUMNH(J)=SUMH                          STAR0724
        525 CONTINUE                                                    STAR0725
            PENMUO(I,J)=PENNUO(I,J)+SUMMO(J)-SUMNO(J)                   STAR0726
            PENMUH(I,J)=PENNUH(I,J)+SUMMH(J)-SUMNH(J)                   STAR0727
            IF(PENMUO(I,J).GT.PMAXO(I)) PMAXO(I)=PENMUO(I,J)            STAR0728
            IF(PENMUH(I,J).GT.PMAXH(I)) PMAXH(I)=PENMUH(I,J)            STAR0729
        530 CONTINUE                                                    STAR0730
      C                                                                 STAR0731
      C     COMPUTE TOTAL FEEDLINE WEIGHTS FOR EACH LINE SIZE           STAR0732
      C                                                                 STAR0733
            IF (SYSNUM.EQ.2) GO TO 550                                  STAR0734
            PDESO(I)=AMAX1(PMAXO(I),PTBTMO(I),PDLO)                     STAR0735
            PDES=PDESO(I)                                               STAR0736
            SUM=0.                                                      STAR0737
            SUMI=0.                                                     STAR0738
            DIA=DPD(I)                                                  STAR0739
            DO 535 MID=1,MIDMLO                                         STAR0740
            IDV=0                                                       STAR0741
            ID=IDMLO(MID)                                               STAR0742
            IM=IMMLO(MID)                                               STAR0743
            II=IIMLO(MID)                                               STAR0744
            SP1=SP1MLO(MID)                                             STAR0745
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      IF(ID.EQ.2) SP1=SP1*ADO(I)                                        STAR0746
      SP2=SP2MLO(MID)                                                   STAR0747
      SP3=SP3MLO(MID)                                                   STAR0748
      IF(ID.EQ.13.OR.ID.EQ.14) IDV=IDO(MID)                             STAR0749
      CALL WTCTRL(PDES,ID,IM,II,DIA,SP1,SP2,SP3,IDV,1,WGT,WI)           STAR0750
      SUM=SUM+WGT                                                       STAR0751
      SUMI=SUMI+WI                                                      STAR0752
  535 CONTINUE                                                          STAR0753
      WMLO(I)=SUM                                                       STAR0754
      WMLIO(I)=SUMI                                                     STAR0755
      SUMT=0.                                                           STAR0756
      SUMIT=0.                                                          STAR0757
      DO 545 NL=1,NEL                                                   STAR0758
      SUM=0.                                                            STAR0759
      SUMI=0.                                                           STAR0760
      MID=MIDELO(NL)                                                    STAR0761
      DIA=OPD(NL)                                                       STAR0762
      DO 540 J=1,MID                                                    STAR0763
      ID=IDELO(NL,J)                                                    STAR0764
      IM=IMELO(NL,J)                                                    STAR0765
      II=IIELO(NL,J)                                                    STAR0766
      IDV=0                                                             STAR0767
      SP1=SP1ELO(NL,J)                                                  STAR0768
      SP2=SP2ELO(NL,J)                                                  STAR0769
      SP3=SP3ELO(NL,J)                                                  STAR0770
      IF(ID.EQ.13.OR.ID.EQ.14) IDV=IDOE(NL,J)                           STAR0771
      CALL WTCTRL(PDES,ID,IM,II,DIA,SP1,SP2,SP3,IDV,1,WGT,WI)           STAR0772
      SUM=SUM+WGT                                                       STAR0773
      SUMI=SUMI+WI                                                      STAR0774
  540 CONTINUE                                                          STAR0775
      WELO(I,NL)=SUM                                                    STAR0776
      WELIO(I,NL)=SUMI                                                  STAR0777
      SUMT=SUMT+SUM                                                     STAR0778
      SUMIT=SUMIT+SUMI                                                  STAR0779
  545 CONTINUE                                                          STAR0780
      WELOT(I)=SUMT                                                     STAR0781
      WELIOT(I)=SUMIT                                                   STAR0782
      WLOT(I)=WMLO(I)+WELOT(I)                                          STAR0783
      WLIOT(I)=WMLIO(I)+WELIOT(I)                                       STAR0784
      WLOTT(I)=WLOT(I)+WLIOT(I)                                         STAR0785
  550 IF (SYSNUM.EQ.1) GO TO 570                                        STAR0786
      PDESH(I)=AMAX1(PMAXH(I),PTBTMH(I),PDLH)                          STAR0787
      PDES=PDESH(I)                                                     STAR0788
      SUM=0.                                                            STAR0789
      SUMI=0.                                                           STAR0790
      DIA=WPD(I)                                                        STAR0791
      DO 555 MID=1,MIDMLH                                               STAR0792
      IDV=0                                                             STAR0793
      ID=IDMLH(MID)                                                     STAR0794
      IM=IMMLH(MID)                                                     STAR0795
      II=IIMLH(MID)                                                     STAR0796
      SP1=SP1MLH(MID)                                                   STAR0797
      IF(ID.EQ.2) SP1=SP1*ADH(I)                                        STAR0798
      SP2=SP2MLH(MID)                                                   STAR0799
      SP3=SP3MLH(MID)                                                   STAR0800
      IF(ID.EQ.13.OR.ID.EQ.14) IDV=IDH(MID)                             STAR0801
      CALL WTCTRL(PDES,ID,IM,II,DIA,SP1,SP2,SP3,IDV,2,WGT,WI)           STAR0802
      SUM=SUM+WGT                                                       STAR0803
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      SUMI=SUMI+WI                                                      STAR0804
  555 CONTINUE                                                          STAR0805
      WMLH(I)=SUM                                                       STAR0806
      WMLIH(I)=SUMI                                                     STAR0807
      SUMT=0.                                                           STAR0808
      SUMIT=0.                                                          STAR0809
      DO 565 NL=1,NEL                                                   STAR0810
      SUM=0.                                                            STAR0811
      SUMI=0.                                                           STAR0812
      MID=MIDELH(NL)                                                    STAR0813
      DIA=WPD(NL)                                                       STAR0814
      DO 560 J=1,MID                                                    STAR0815
      ID=IDELH(NL,J)                                                    STAR0816
      IM=IMELH(NL,J)                                                    STAR0817
      II=IIELH(NL,J)                                                    STAR0818
      IDV=0                                                             STAR0819
      SP1=SP1ELH(NL,J)                                                  STAR0820
      SP2=SP2ELH(NL,J)                                                  STAR0821
      SP3=SP3ELH(NL,J)                                                  STAR0822
      IF(ID.EQ.13.OR.ID.EQ.14) IDV=ICHE(NL,J)                           STAR0823
      CALL WTCTRL(PDES,ID,IM,II,DIA,SP1,SP2,SP3,IDV,2,WGT,WI)           STAR0824
      SUM=SUM+WGT                                                       STAR0825
      SUMI=SUMI+WI                                                      STAR0826
  560 CONTINUE                                                          STAR0827
      WELH(I,NL)=SUM                                                    STAR0828
      WELIH(I,NL)=SUMI                                                  STAR0829
      SUMT=SUMT+SUM                                                     STAR0830
      SUMIT=SUMIT+SUMI                                                  STAR0831
  565 CONTINUE                                                          STAR0832
      WELHT(I)=SUMT                                                     STAR0833
      WELIHT(I)=SUMIT                                                   STAR0834
      WLHT(I)=WMLH(I)+WELHT(I)                                          STAR0835
      WLIHT(I)=WMLIH(I)+WELIHT(I)                                       STAR0836
      WLHTT(I)=WLHT(I)+WLIHT(I)                                         STAR0837
  570 CONTINUE                                                          STAR0838
C                                                                       STAR0839
C     WRITE OUT THE GIMMICK                                             STAR0840
C                                                                       STAR0841
C                                                                       STAR0842
      IPASS = IPASS + 1                                                 STAR0843
      IF (IPASS.GT.1) GO TO 590                                         STAR0844
C                                                                       STAR0845
      WRITE (6,575)                                                     STAR0846
  575 FORMAT(1H1,//////)                                                STAR0847
      WRITE (6,580)                                                     STAR0848
  580 FORMAT(//T123,'*',/T33,'SSSSS',T42,'SSSSSS',T51,'SSSSS',T58,'SSS',STAR0849
     1T63,'SS    S',T111,'EEEEEEE',T121,'*',/T33,'S',T38,'S',T42,'S',T50,STAR0850
     2'S',T59,'S',T63,'S S   S',T96,'+++++++++++++X+E',T116,'E  *',/T33,STAR0851
     3'SSSSS',T42,'SSSS',T50,'S',T54,'SS',T59,'S',T63,'S  S  S',T96,'+',STAR0852
     4T111,'E',T116,'E*',/T33,'S    S',T42,'S',T50,'S    S',T59,'S',T63,STAR0853
     5'S   S S',T96,'+',T107,'¤¤X¤E    E  *',  /T33,'SSSSS',T42,'SSSSSSSTAR0854
     6',T51,'SSSSS',T58,'SSS',T63,'S    SS',T96,'+',T107,'¤',T111,'EEEEESTAR0855
     7E',T121,'*',/T96,'+',T107,'¤',T123,'*',/T96,'+',T107,'¤',/T7,'SSSSSTAR0856
     8SS',T16,'SSSSS',T26,'S',T33,'SSSSS',T42,'SSSSS',T55,'SSSSS',T63,  STAR0857
     9'SSSSS',T74,'S',T81,'SS    S',T96,'+',T107,'¤',/T7,'S',T18,'S',   STAR0858
     AT25,'S S',T33,'S    S',T44,'S',T57,'S',T63,'S    S',T73,'S S',T81,STAR0859
     B'S S   S',T96,'+',T107,'¤',T123,'*',/T7,'SSSSSS',T18,'S',T24,'SSSSSTAR0860
     CS',T33,'SSSSS',T44,'S',T49,'XXXX',T57,'S',T63,'SSSSS',T72,'SSSSS',STAR0861
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      DT81,'S  S  S',T96,'+',T107,'o',T111,'EEEEEE',T121,'*',/T12,'S',    STAR0842
      ET18,'S',T23,'S',T29,'S',T33,'S  S',T44,'S',T57,'S',T63,'S  S',T71,STAR0843
      E'S     S',T81,                                                     STAR0844
      F'S   S S',T96,'+++++++++++++++X+E',T116,'E',T119,'*',/T7,'SSSSSS',  STAR0845
      GT18,'S',T22,'S',T30,'S',T33,'S   S',T44,'S',T57,'S',T63,'S   S',   STAR0846
      HT70,'S',T78,'S',T81,'S    SS',T96,'+',T107,'o',T111,'E    E*')     STAR0847
       WRITE (6,585)                                                      STAR0848
  585 FORMAT(T96,'+',T107,'ooXoE    E  *',/T96,'+',T107,'o',T111,'EEEEEESTAR0849
     1',T121,'*',/T96,'+',T107,'P',T123,'*',/T96,'+',T107,'V',/T47,'++++STAR0850
     2++++++PVC++++++++++++++++++++++++++PVC++++++++++',T107,'C',/T47,'+',STAR0851
     3T107,'o',/T47,'X',T107,'X',/T47,'*',T107,'*',/T24,'*  *  *  *  *  STAR0852
     4*  *  * Z * *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  STAR0853
     5* Z * * * * *',/T21,'*',T37,'*',T47,'X',T107,'X',T112,'*',T117,    STAR0854
     6'*',/T18,'*',T38,'*',T47,'+',T107,'o',T114,'*',T117,'*',/T15,'*',  STAR0855
     7T39,'*',T47,'+',T107,'o',T116,'*',/T12,'*',T40,'*',T47,'+',T107,   STAR0856
     8'o',T118,'*',/T9,'*',T41,'*',T47,'+',T107,'o',T120,'*',/T6,'*',    STAR0857
     9T42,'*+++++',T107,'ooooooooooooo',T121,'*',/T9,'*',T41,'*',T120,   STAR0858
     A'*',/T12,'*',T40,'*',T118,'*',/T15,'*',T39,'*',T116,'*',/T18,'*',  STAR0859
     BT38,'*',T114,'*  *',/T21,'*',T37,'*',T112,'*',T117,'*',/T24,'*  *  STAR0860
     C *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  STAR0861
     D *  *  *  * * * * * * *',////T30,'A PARAMETRIC PROPULSION SYSTEMS  STAR0862
     ESTART TRANSIENT ANALYSIS PROGRAM',////T100,'PROGRAM I.D. -  FD13063STAR0863
     F',/T100,'PROGRAMMER - R.F.HAUSMAN',/T100,'DEPT. 62-13, BLDG. 104')STAR0864
  590 CONTINUE                                                           STAR0865
C                                                                        STAR0866
C     WRITE OUT THE INPUT DATA TABLE                                     STAR0867
C                                                                        STAR0868
      WRITE (6,785)                                                      STAR0869
      WRITE (6,790)(ST(I),I=1,7)                                         STAR0870
      WRITE (6,595)                                                      STAR0871
  595 FORMAT(1H0,T20,'INPUT DATA FOR START TRANSIENT PROBLEM CONSIDERED  STAR0872
     1IN THIS ANALYSIS,',//)                                             STAR0873
      WRITE (6,600)NSIZE                                                 STAR0874
  600 FORMAT(T5,'THE NUMBER OF LINE SIZES TO BE CONSIDERED IS  ',I5)     STAR0875
      GO TO (605,615,625),SYSNUM                                         STAR0876
  605 WRITE (6,610)                                                      STAR0877
  610 FORMAT(T5,'THE PROBLEM CONSIDERS THE OXIDIZER FEED SYSTEM')        STAR0878
      GO TO 635                                                          STAR0879
  615 WRITE (6,620)                                                      STAR0880
  620 FORMAT(T5,'THE PROBLEM CONSIDERS THE FUEL FEED SYSTEM')            STAR0881
      GO TO 635                                                          STAR0882
  625 WRITE (6,630)                                                      STAR0883
  630 FORMAT(T5,'THE PROBLEM CONSIDERS BOTH OXIDIZER AND FUEL FEED SYSTESTAR0884
     1MS')                                                               STAR0885
  635 CONTINUE                                                           STAR0886
      WRITE (6,640)NOP1,NOP,WDOTNO,WDOTNH,VWGTN,FNOM                     STAR0887
  640 FORMAT(T5,'THE NUMBER OF ENGINES FOR THE VEHICLE IS ',I5,          STAR0888
     1/T5,'THE NUMBER OF ENGINES FOR EACH FEED SYSTEM IS ',I5,           STAR0889
     2    /T5,'THE NOMINAL OXIDIZER FLOW RATE IS',F8.2,' LBS/SEC',/T5,'TSTAR0890
     3HE NOMINAL FUEL FLOW RATE IS',F8.2,' LBS/SEC',/T5,'THE VEHICLE LOASTAR0891
     4DED WEIGHT IS',F12.2,' LBS',/T5,'THE NOMINAL THRUST FOR EACH ENGINSTAR0892
     5E IS',F10.2,' LBS')                                                STAR0893
      WRITE (6,645)TENINO,TENINH,PENTOL,HEADIO,OXHTLN,HEADIH,HYHTLN,ULVLSTAR0894
     1IO,ULVLIH,LOADO1,LOADH1,ASKIN,ADOME,ATGT                           STAR0895
  645 FORMAT(T5,'THE BULK OXID. ENGINE INLET TEMPERATURE IS',F8.2,' DEG.STAR0896
     1R',/T5,'THE BULK FUEL ENGINE INLET TEMPERATURE IS',F8.2,' DEG.R', STAR0897
     3                                                    /T5,'THE STAR0898
     4COMPONENT PRESSURE TOLERANCE IS',F6.2,' PSI',/T5,'THE OXID. HEAD HSTAR0899
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Fig. B-1 STAR Program Listing (Cont'd)

```
920.        5EIGHT IN THE TANK IS',F8.3,' FT',/T5,'THE OXID. HEAD HEIGHT IN THESTAR0920
921.        6FEED LINE IS',F8.3,' FT',/T5,'THE FUEL HEAD HEIGHT IN THE TANK IS'STAR0921
922.        7,F8.3,' FT',/T5,'THE FUEL HEAD HEIGHT IN THE FEED LINE IS',F8.3,  STAR0922
923.        8'FT',/T5,'THE INITIAL ULLAGE VOLUME IN THE OXIDIZER TANK IS',F10.0STAR0923
924.        9,'CU.FT',/T5,'THE INITIAL ULLAGE VOLUME IN THE FUEL TANK IS',F10.0STAR0924
925.        A,' CU.FT',/T5,'THE INITIAL OXIDIZER LOADING IS',F12.0,' LBS',/T5,'STAR0925
926.        BTHE INITIAL FUEL LOADING IS',F12.0,' LBS',/T5,'THE EXTERNAL SURFACSTAR0926
927.        CE AREA OF THE DROP TANK IS',F12.1,' SQ. FT.',/T5,'THE EXTERNAL SURSTAR0927
928.        DFACE AREA OF THE LOX/LH2 BULKHEAD IS',F8.1,' SQ. FT.',/T5,'THE TOTSTAR0928
929.        EAL SURFACE AREA IS THEREFORE',F12.1,' SQ. FT.')                    STAR0929
930.         WRITE (6,650)PDLO,PDLH                                             STAR0930
931.      650 FORMAT(T5,'THE OXYGEN FEEDLINE DESIGN PRESSURE IS',G13.8,' PSI',/ STAR0931
932.        1T5,'THE HYDROGEN FEEDLINE DESIGN PRESSURE IS',G13.8,' PSI')        STAR0932
933.         WRITE (6,785)                                                      STAR0933
934.         WRITE (6,665)                                                      STAR0934
935.         WRITE (6,655)                                                      STAR0935
936.      655 FORMAT(T5,'THE TANK GEOMETRY INPUT VALUES ARE AS FOLLOWS - ',',/)  STAR0936
937.         WRITE (6,660)(EQLR1(N),N=1,9)                                      STAR0937
938.      660 FORMAT(T5,'L1=',F8.3,T17,'L2=',F8.3,T29,'L3=',F8.3,T41,'L4=',F8.3,STAR0938
939.        1T53,'R1=',F8.3,T65,'R2=',F8.3,T77,'R3=',F8.3,T89,'R4=',F8.3,T101, STAR0939
940.        2'R5=',F8.3)                                                       STAR0940
941.         WRITE (6,665)                                                      STAR0941
942.      665 FORMAT(1H0)                                                       STAR0942
943.         WRITE (6,670)                                                      STAR0943
944.      670 FORMAT(T36,'TABLE OF FEED LINE DATA',/T20,'OXIDIZER LINES',T60,'FUSTAR0944
945.        1EL LINES',//T10,'DIAMETER',T22,'LENGTH',T32,'K-FACTOR',T50,'DIAMETSTAR0945
946.        2ER',T62,'LENGTH',T72,'K-FACTOR',/T11,'INCHES',T21,'FEET',T51,'INCHSTAR0946
947.        3ES',T63,'FEET',/)                                                 STAR0947
948.         DO 685 K=1,NSIZE                                                   STAR0948
949.         IF (K.GT.NEL) GO TO 675                                            STAR0949
950.         WRITE (6,680)DPD(K),DPIPEL(K),DKPD(K),HPD(K),HPIPEL(K),HKPD(K)     STAR0950
951.         GO TO 685                                                          STAR0951
952.      675 WRITE (6,680)DPD(K),TOTMLO,DKPD(K),HPD(K),TOTMLH,HKPD(K)          STAR0952
953.      680 FORMAT(T11,F6.2,T21,F7.2,T33,F7.4,T51,F6.2,T61,F7.2,T73,F7.4)     STAR0953
954.      685 CONTINUE                                                          STAR0954
955.         WRITE (6,665)                                                      STAR0955
956.         IF (SYSNUM.EQ.2) GO TO 730                                         STAR0956
957.         WRITE (6,695)                                                      STAR0957
958.      695 FORMAT(T15,'COMPONENT DESCRIPTORS FOR MAIN OXYGEN FEEDLINE',//)   STAR0958
959.         WRITE (6,700)                                                      STAR0959
960.      700 FORMAT(T5,'COMPONENT   TYPE  MATL  INSUL    SPEC1      SPEC2      STAR0960
961.        1  SPEC3',/)                                                       STAR0961
962.         DO 705 I=1,MIDMLO                                                  STAR0962
963.      705 WRITE (6,710)I,IDMLO(I),IMMLO(I),IIMLO(I),SP1MLO(I),SP2MLO(I),SP3MSTAR0963
964.        1LO(I)                                                             STAR0964
965.      710 FORMAT(T7,I3,T17,I3,T23,I2,T30,I2,T36,G9.4,T47,G9.4,T58,G9.4)     STAR0965
966.         DO 725 NL=1,NEL                                                    STAR0966
967.         MID=MIDELO(NL)                                                     STAR0967
968.         WRITE (6,715)NL                                                    STAR0968
969.      715 FORMAT(1H0,T14,'COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NSTAR0969
970.        1UMBER ',I1,/)                                                     STAR0970
971.         WRITE (6,700)                                                      STAR0971
972.         DO 720 I=1,MID                                                     STAR0972
973.      720 WRITE (6,710)I,IDELO(NL,I),IMELO(NL,I),IIELO(NL,I),SP1ELO(NL,I),SPSTAR0973
974.        12ELO(NL,I),SP3ELO(NL,I)                                           STAR0974
975.      725 CONTINUE                                                          STAR0975
976.      730 IF (SYSNUM.EQ.1) GO TO 760                                        STAR0976
977.         WRITE (6,735)                                                      STAR0977
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      735 FORMAT(T15,'COMPONENT DESCRIPTORS FOR MAIN HYDROGEN FEEDLINE',//) STAR0978
          WRITE (6,730)                                                    STAR0979
          DO 740 I=1,MIDMLH                                                STAR0980
      740 WRITE (6,710)I,IDMLH(I),IMMLH(I),IIMLH(I),SP1MLH(I),SP2MLH(I),SP3MSTAR0981
         1LH(I)                                                            STAR0982
          DO 755 NL=1,NEL                                                  STAR0983
          MID=MIDELH(NL)                                                   STAR0984
          WRITE (6,745)N                                                   STAR0985
      745 FORMAT(1HC,T14,'COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINESTAR0986
         1 NUMBER ',I1,/)                                                  STAR0987
          WRITE (6,730)                                                    STAR0988
          DO 750 I=1,MID                                                   STAR0989
      750 WRITE (6,710)I,IDELH(NL,I),IMELH(NL,I),IIELH(NL,I),SP1ELH(NL,I),SPSTAR0990
         12ELH(NL,I),SP3ELH(NL,I)                                          STAR0991
      755 CONTINUE                                                         STAR0992
      760 CONTINUE                                                         STAR0993
          WRITE (6,785)                                                    STAR0994
          WRITE (6,765)                                                    STAR0995
      765 FORMAT(1HC,T20,'THE TIME DEPENDENT PERFORMANCE CHARACTERISTIC INPUSTAR0996
         1T VALUES ARE AS FOLLOWS - ,')                                    STAR0997
          WRITE (6,770)                                                    STAR0998
      770 FORMAT(1HO,T5,'TIME',T15,'NPSPO',T25,'NPSPH',T35,'WDTFRO',T45,'WDTSTAR0999
         1FRH',T55,'FIFRAC',T65,'PENMNO',T75,'PENMNH',T85,'PPDGOT',T95,'PPDGSTAR1000
         2HT',T106,'TDGOT',T116,'TDGHT')                                   STAR1001
          DO 780 N=1,NPTS                                                  STAR1002
          WRITE (6,775)TIMEA(N),NPSPO(N),NPSPH(N),WDTFRO(N),WDTFRH(N),FIFRACSTAR1003
         1(N),PENMNO(N),PENMNH(N),PPDGOT(N),PPDGHT(N),TDGOT(N),TDGHT(N)    STAR1004
      775 FORMAT(T3,F6.2,T14,F6.2,T24,F6.2,T35,F6.3,T45,F6.3,T55,F6.3,T65,  STAR1005
         1F6.2,T75,F6.2,T85,F6.2,T95,F6.2,T105,F6.2,T115,F6.2)             STAR1006
      780 CONTINUE                                                         STAR1007
C                                                                          STAR1008
C     WRITE OUT THE SINGLY SUBSCRIPTED VARIABLES TABLE                     STAR1009
C                                                                          STAR1010
          WRITE (6,785)                                                    STAR1011
      785 FORMAT(1H1)                                                      STAR1012
          WRITE (6,790)(ST(I),I=1,7)                                       STAR1013
      790 FORMAT(T42,7A6,//)                                               STAR1014
          WRITE (6,795)                                                    STAR1015
      795 FORMAT(T3,'TRANS',T14,'WDOOT',T24,'WDOOT',T33,'VEHICLE',T45,'T/W'STAR1016
         1,T53,'DELPHD',T63,'DELPHD',T73,'PROP-O',T83,'PROP-F',T92,'PROP-TOTSTAR1017
         2',T104,'PENG',T114,'PENG')                                       STAR1018
          WRITE (6,800)                                                    STAR1019
      800 FORMAT(T4,'TIME',T14,'OXID.',T24,'FUEL',T33,'WEIGHT',T44,'RATIO', STAR1020
         1T54,'OXID.',T64,'FUEL',T74,'INCR',T84,'INCR',T94,'CUM',T104,     STAR1021
         2'OXID',T114,'FUEL',//)                                           STAR1022
          DO 820 N=1,NPTS                                                  STAR1023
          WRITE (6,805)TIMEA(N)                                            STAR1024
      805 FORMAT(T2,F6.2)                                                  STAR1025
          IF (N.EQ.NPTS) GO TO 815                                         STAR1026
          WRITE (6,810)WDOOTO(N),WDOOTH(N),VWGTNU(N),FTOW(N),DLPHDO(N),DLPHDSTAR1027
         1H(N),PCWGTO(N),PCWGTH(N),PROWGT(N),PENGO(N),PENGH(N)             STAR1028
      810 FORMAT(T12,F8.3,T22,F8.3,T32,F10.2,T44,F5.3,T53,F6.2,T63,F6.2,T71,STAR1029
         1F8.3,T81,F8.3,T91,F10.3,T103,F6.2,T113,F6.2)                     STAR1030
      815 CONTINUE                                                         STAR1031
      820 CONTINUE                                                         STAR1032
C                                                                          STAR1033
C     WRITE OUT THE DELTA-P ACCELERATION DATA ARRAY AS F(T)                STAR1034
C                                                                          STAR1035
```

Fig. B-1 STAR Program Listing (Cont'd)

```
1036.          NMA=NELP+11                                                    STAR1036
1037.          GO TO (825,875,825),SYSNUM                                     STAR1037
1038.      825 WRITE (6,830)                                                  STAR1038
1039.      830 FORMAT(1H1)                                                    STAR1039
1040.          WRITE (6,835)(ST(I),I=1,7)                                     STAR1040
1041.      835 FORMAT(T23,7A6,T66,'- OXYGEN SUPPLY SYSTEM')                   STAR1041
1042.          WRITE (6,840)                                                  STAR1042
1043.      840 FORMAT(1HO,T38,'DELTA-P TO SUPPLY ACCELERATION HEAD')          STAR1043
1044.          WRITE (6,845)(OPD(K),K=NELP,NMA)                               STAR1044
1045.      845 FORMAT(1HO,T2,'DELTA',T8 ,F4.1,' INCH',T19,F4.1,' INCH',T30,F4.1, STAR1045
1046.         1' INCH',T40,F4.1,' INCH',T50,F4.1,' INCH',T60,F4.1,' INCH',T70, STAR1046
1047.         2F4.1,' INCH',T80,F4.1,' INCH',T90,F4.1,' INCH',T100,F4.1,' INCH',TSTAR1047
1048.         3110,F4.1,' INCH',T120,F4.1,' INCH')                            STAR1048
1049.          WRITE (6,850)                                                  STAR1049
1050.      850 FORMAT(T2,'TIME',T8 ,' MAIN LINE',T19,' MAIN LINE',T30,'MAIN LINE'STAR1050
1051.         1,T40,'MAIN LINE',T50,'MAIN LINE',T60,'MAIN LINE',T70 ,'MAIN LINE',STAR1051
1052.         2T80 ,'MAIN LINE',T90,'MAIN LINE',T100,'MAIN LINE',T110,'MAIN LINE'STAR1052
1053.         3,T120,'MAIN LINE'/)                                            STAR1053
1054.          DO 870 N=1,NPTS                                                STAR1054
1055.          WRITE (6,855)TIMEA(N)                                          STAR1055
1056.      855 FORMAT(T2,F5.2)                                                STAR1056
1057.          IF (N.EQ.NPTS) GO TO 865                                       STAR1057
1058.          WRITE (6,860)(DLPACO(I,N),I=NELP,NMA)                          STAR1058
1059.      860 FORMAT(T9 ,F8.3,T19,F8.3,T31,F8.3,T41,F8.3,T51,F8.3,T61,F8.3,  STAR1059
1060.         1T71,F8.3,T81,F8.3,T91,F8.3,T101,F8.3,T111,F8.3,T121,F8.3)      STAR1060
1061.      865 CONTINUE                                                       STAR1061
1062.      870 CONTINUE                                                       STAR1062
1063.      875 CONTINUE                                                       STAR1063
1064.          IF (SYSNUM.EQ.1) GO TO 895                                     STAR1064
1065.          WRITE (6,830)                                                  STAR1065
1066.          WRITE (6,880)(ST(I),I=1,7)                                     STAR1066
1067.      880 FORMAT(T23,7A6,T66,'- HYDROGEN SUPPLY SYSTEM')                 STAR1067
1068.          WRITE (6,840)                                                  STAR1068
1069.          WRITE (6,845)(HPD(K),K=NELP,NMA)                               STAR1069
1070.          WRITE (6,850)                                                  STAR1070
1071.          DO 890 N=1,NPTS                                                STAR1071
1072.          WRITE (6,855)TIMEA(N)                                          STAR1072
1073.          IF (N.EQ.NPTS) GO TO 885                                       STAR1073
1074.          WRITE (6,860)(DLPACH(I,N),I=NELP,NMA)                          STAR1074
1075.      885 CONTINUE                                                       STAR1075
1076.      890 CONTINUE                                                       STAR1076
1077.      895 CONTINUE                                                       STAR1077
1078.C                                                                       STAR1078
1079.C     WRITE OUT THE DELTA-P LINE LOSS DATA ARRAY AS F(T)                 STAR1079
1080.C                                                                       STAR1080
1081.          GO TO (900,925,900),SYSNUM                                     STAR1081
1082.      900 WRITE (6,830)                                                  STAR1082
1083.          WRITE (6,835)(ST(I),I=1,7)                                     STAR1083
1084.          WRITE (6,905)                                                  STAR1084
1085.      905 FORMAT(1HO,T26,'DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSTAR1085
1086.         1SES')                                                          STAR1086
1087.          WRITE (6,845)(OPD(K),K=NELP,NMA)                               STAR1087
1088.          WRITE (6,850)                                                  STAR1088
1089.          DO 920 N=1,NPTS                                                STAR1089
1090.          WRITE (6,855)TIMEA(N)                                          STAR1090
1091.          IF (N.EQ.NPTS) GO TO 915                                       STAR1091
1092.          WRITE (6,910)(DLPLNO(I,N),I=NELP,NMA)                          STAR1092
1093.      910 FORMAT(T9 ,E8.4,T19,E8.4,T31,E8.4,T41,E8.4,T51,E8.4,T61,E8.4,  STAR1093
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Fig. B-1 STAR Program Listing (Cont'd)

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1094,        1T71,F8.4,T81,E8.4,T91,E8.4,T101,E8.4,T111,E8.4,T121,E8.4)          STAR1094
1095,      915 CONTINUE                                                         STAR1095
1096,      920 CONTINUE                                                         STAR1096
1097,      925 CONTINUE                                                         STAR1097
1098,          IF (SYSNUM,EQ,1) GO TO 940                                       STAR1098
1099,          WRITE (6,830)                                                    STAR1099
1100,          WRITE (6,880)(ST(I),I=1,7)                                       STAR1100
1101,          WRITE (6,905)                                                    STAR1101
1102,          WRITE (6,845)(HPD(K),K=NELP,NMA)                                 STAR1102
1103,          WRITE (6,850)                                                    STAR1103
1104,          DO 935 N=1,NPTS                                                  STAR1104
1105,          WRITE (6,855)TIMEA(N)                                            STAR1105
1106,          IF (N,EQ,NPTS) GO TO 930                                         STAR1106
1107,          WRITE (6,910)(DLPLNH(I,N),I=NELP,NMA)                            STAR1107
1108,      930 CONTINUE                                                         STAR1108
1109,      935 CONTINUE                                                         STAR1109
1110,      940 CONTINUE                                                         STAR1110
1111,    C                                                                      STAR1111
1112,    C     WRITE OUT THE ENGINE FEEDLINE PRESSURE DROPS                     STAR1112
1113,    C                                                                      STAR1113
1114,          IF (SYSNUM,EQ,2) GO TO 975                                       STAR1114
1115,          WRITE (6,830)                                                    STAR1115
1116,          WRITE (6,945)(ST(I),I=1,7)                                       STAR1116
1117,      945 FORMAT(T23,7A6,T66,'-OXYGEN ENGINE FEEDLINE SYSTEM')             STAR1117
1118,          WRITE (6,950)                                                    STAR1118
1119,      950 FORMAT(1HO,T13,'DELTA-P TO SUPPLY ACCELERATION HEAD',T64,'DELTA-P STAR1119
1120,         1DUE TO LINE FRICTION AND CONFIGURATION LOSSES',//T2,'DELTA',T13, STAR1120
1121,         2'ENGINE',T26,'ENGINE',T39,'ENGINE',T52,'ENGINE',T65,'ENGINE',T78, STAR1121
1122,         3'ENGINE',T91,'ENGINE',T104,'ENGINE',/T2,'TIME',T13,'LINE NO 1',  STAR1122
1123,         4T26,'LINE NO 2',T39,'LINE NO 3',T52,'LINE NO 4',T65,'LINE NO 1', STAR1123
1124,         5T78,'LINE NO 2',T91,'LINE NO 3',T104,'LINE NO 4')               STAR1124
1125,          DO 970 N=1,NPTS                                                  STAR1125
1126,          WRITE (6,855)TIMEA(N)                                            STAR1126
1127,          IF (N,EQ,NPTS) GO TO 970                                         STAR1127
1128,          IF (NEL,EQ,4) GO TO 960                                          STAR1128
1129,          DO 955 I=NELP,4                                                  STAR1129
1130,          DLPACO(I,N)=0.                                                   STAR1130
1131,          DLPLNO(I,N)=0.                                                   STAR1131
1132,      955 CONTINUE                                                         STAR1132
1133,      960 WRITE (6,965)(DLPACO(I,N),I=1,4),(DLPLNO(I,N),I=1,4)             STAR1133
1134,      965 FORMAT(10X,8G13,8)                                               STAR1134
1135,      970 CONTINUE                                                         STAR1135
1136,          IF (SYSNUM,EQ,1) GO TO 1000                                      STAR1136
1137,      975 WRITE (6,830)                                                    STAR1137
1138,          WRITE (6,980)(ST(I),I=1,7)                                       STAR1138
1139,      980 FORMAT(T23,7A6,T66,'-HYDROGEN ENGINE FEEDLINE SYSTEM')           STAR1139
1140,          WRITE (6,950)                                                    STAR1140
1141,          DO 995 N=1,NPTS                                                  STAR1141
1142,          WRITE (6,855)TIMEA(N)                                            STAR1142
1143,          IF (N,EQ,NPTS) GO TO 995                                         STAR1143
1144,          IF (NEL,EQ,4) GO TO 990                                          STAR1144
1145,          DO 985 I=NELP,4                                                  STAR1145
1146,          DLPACH(I,N)=0.                                                   STAR1146
1147,          DLPLNH(I,N)=0.                                                   STAR1147
1148,      985 CONTINUE                                                         STAR1148
1149,      990 WRITE (6,965)(DLPACH(I,N),I=1,4),(DLPLNH(I,N),I=1,4)             STAR1149
1150,      995 CONTINUE                                                         STAR1150
1151,     1000 CONTINUE                                                         STAR1151
```

Fig. B-1 STAR Program Listing (Cont'd)

```
1152,   C                                                                       STAR1152
1153,   C     WRITE OUT THE ULLAGE PRESSURE REQUIREMENTS AS F(T)                 STAR1153
1154,   C                                                                       STAR1154
1155,         GO TO (1005,1030,1005),SYSNUM                                     STAR1155
1156,    1005 WRITE (6,830)                                                     STAR1156
1157,         WRITE (6,835)(ST(I),I=1,7)                                        STAR1157
1158,         WRITE (6,1010)VOP                                                 STAR1158
1159,    1010 FORMAT(1H0,T30,'ULLAGE PRESSURE REQUIRED FOR',I3,' ENGINE OPERATIOSTAR1159
1160,        1N')                                                               STAR1160
1161,         WRITE (6,845)(PD(K),K=NELP,NMA)                                   STAR1161
1162,         WRITE (6,850)                                                     STAR1162
1163,         DO 1025 N=1,NPTS                                                  STAR1163
1164,         WRITE (6,855)TIMEA(N)                                             STAR1164
1165,         IF (N.EQ.NPTS) GO TO 1020                                         STAR1165
1166,         WRITE (6,1015)(PULLO(I,N),I=NELP,NMA)                             STAR1166
1167,    1015 FORMAT(T9,F8.3,T19,F8.3, T31,F8.3,T41,F8.3,T51,F8.3,T61,F8.3,     STAR1167
1168,        1T71,F8.3,T81,F8.3,T91,F8.3,T101,F8.3,T111,F8.3,T121,F8.3)        STAR1168
1169,    1020 CONTINUE                                                          STAR1169
1170,    1025 CONTINUE                                                          STAR1170
1171,    1030 CONTINUE                                                          STAR1171
1172,         IF (SYSNUM.EQ.1) GO TO 1045                                       STAR1172
1173,         WRITE (6,830)                                                     STAR1173
1174,         WRITE (6,880)(ST(I),I=1,7)                                        STAR1174
1175,         WRITE (6,1010)VOP                                                 STAR1175
1176,         WRITE (6,845)(PD(K),K=NELP,NMA)                                   STAR1176
1177,         WRITE (6,850)                                                     STAR1177
1178,         DO 1040 N=1,NPTS                                                  STAR1178
1179,         WRITE (6,855)TIMEA(N)                                             STAR1179
1180,         IF (N.EQ.NPTS) GO TO 1035                                         STAR1180
1181,         WRITE (6,1015)(PULLH(I,N),I=NELP,NMA)                             STAR1181
1182,    1035 CONTINUE                                                          STAR1182
1183,    1040 CONTINUE                                                          STAR1183
1184,    1045 CONTINUE                                                          STAR1184
1185,   C                                                                       STAR1185
1186,   C     WRITE OUT THE MINIMUM ULLAGE PRESSURE REQUIRED, THE PRESSURE ON   STAR1186
1187,   C     THE TANK BOTTOMS AND THE LINE HEAD PRESSURES                      STAR1187
1188,   C                                                                       STAR1188
1189,         WRITE (6,785)                                                     STAR1189
1190,         WRITE (6,790)(ST(I),I=1,7)                                        STAR1190
1191,         WRITE (6,1050)                                                    STAR1191
1192,    1050 FORMAT(T2, 'PRESSURE AND VOLUME VALUES FOR FLUID VAPOR,MIN,ULLAGE,STAR1192
1193,        1TANK BOTTOM,LINE HEAD,ULLAGE VOLUME,TANK HEAD HEIGHT AND ULLAGE WESTAR1193
1194,        2IGHT',/)                                                          STAR1194
1195,         WRITE (6,1055)                                                    STAR1195
1196,    1055 FORMAT(T3,'TRANS,',T13,'ULLVAP',T21,'ULLVAP',T29,'MINULL',T37,'MINSTAR1196
1197,        1ULL',T45,'TNKBOT',T53,'TNKBOT',T61,'LINHED',T69,'LINHED',T78,'ULLVSTAR1197
1198,        2OL',T87,'ULLVOL',T95,'TNKHED',T103,'TNKHED',T112,'ULLWGT',T121,   STAR1198
1199,        3'ULLWGT')                                                         STAR1199
1200,         WRITE (6,1060)                                                    STAR1200
1201,    1060 FORMAT(T4,'TIME',T14,'OXID.',T22,'FUEL',T30,'OXID.',T38,'FUEL',T46STAR1201
1202,        1,'OXID.',T54,'FUEL',T62,'OXID.',T70,'FUEL',T79,'OXID.',T88,'FUEL',STAR1202
1203,        2T96,'OXID.',T104,'FUEL',T113,'OXID.',T122,'FUEL')                 STAR1203
1204,         WRITE (6,1065)                                                    STAR1204
1205,    1065 FORMAT(T5,'SEC',T14,'PSIA',T22,'PSIA',T30,'PSIA',T38,'PSIA',T46,'PSTAR1205
1206,        1SIA',T54,'PSIA',T62,'PSIA',T70,'PSIA',T78,'CU.FT.',T87,'CU.FT.',  STAR1206
1207,        2T97,'FT.',T105,'FT.',T114,'LBS',T122,'LBS',/)                     STAR1207
1208,         DO 1080 N=1,NPTS                                                  STAR1208
1209,         WRITE (6,1070)TIMEA(N)                                            STAR1209
```

Fig. B-1 STAR Program Listing (Cont'd)

```
1070 FORMAT(T2,F6.2)                                                    STAR1210
     IF (N.EQ.NPTS) GO TO 1080                                          STAR1211
     I=NELP                                                             STAR1212
     WRITE (6,1075)PUVAPO,PUVAPH,PULLRO(I,N),PULLRH(I,N),PTKBTO(I,N),PTSTAR1213
    1KBTH(I,N),PHDLNO(N),PHDLNH(N),LLVLO2(N),ULVLH2(N),HEADO2(N),HEADH2STAR1214
    2(N),ATULGO(N),ATULGH(N)                                            STAR1215
1075 FORMAT(T13,F6.3,T21,F6.3,T29,F6.2,T37,F6.2,T45,F6.2,T53,F6.2,T61, STAR1216
    1F6.2,T69,F6.3,T77,F7.1,T86,F7.1,T95,F6.2,T103,F6.2,T111,F7.1,T120,STAR1217
    2F7.1)                                                              STAR1218
1080 CONTINUE                                                           STAR1219
1085 CONTINUE                                                           STAR1220
C                                                                       STAR1221
C    WRITE OUT MINIMUM REQUIRED ULLAGE PRESSURES                        STAR1222
C                                                                       STAR1223
     GO TO (1090,1110,1090),SYSNUM                                      STAR1224
1090 WRITE (6,830)                                                      STAR1225
     WRITE (6,835)(ST(N),N=1,7)                                         STAR1226
     WRITE (6,1095)NOP                                                  STAR1227
1095 FORMAT(1H0,T20,'MINIMUM REQUIRED ULLAGE PRESSURE FOR',I3,' ENGINE STAR1228
    1OPERATION PER MAIN FEED LINE')                                     STAR1229
     WRITE (6,845)(OPD(K),K=NELP,NMA)                                   STAR1230
     WRITE (6,850)                                                      STAR1231
     DO 1105 N=1,NPTS                                                   STAR1232
     WRITE (6,855)TIMEA(N)                                              STAR1233
     IF (N.EQ.NPTS) GO TO 1100                                          STAR1234
     WRITE (6,1015)(PULLRO(I,N),I=NELP,NMA)                             STAR1235
1100 CONTINUE                                                           STAR1236
1105 CONTINUE                                                           STAR1237
1110 CONTINUE                                                           STAR1238
     IF (SYSNUM.EQ.1) GO TO 1125                                        STAR1239
     WRITE (6,830)                                                      STAR1240
     WRITE (6,880)(ST(N),N=1,7)                                         STAR1241
     WRITE (6,1095)NOP                                                  STAR1242
     WRITE (6,845)(OPD(K),K=NELP,NMA)                                   STAR1243
     WRITE (6,850)                                                      STAR1244
     DO 1120 N=1,NPTS                                                   STAR1245
     WRITE (6,855)TIMEA(N)                                              STAR1246
     IF (N.EQ.NPTS) GO TO 1115                                          STAR1247
     WRITE (6,1015)(PULLRH(I,N),I=NELP,NMA)                             STAR1248
1115 CONTINUE                                                           STAR1249
1120 CONTINUE                                                           STAR1250
1125 CONTINUE                                                           STAR1251
C                                                                       STAR1252
C    WRITE OUT THE TANK BOTTOM PRESSURES                                STAR1253
C                                                                       STAR1254
     GO TO (1130,1150,1130),SYSNUM                                      STAR1255
1130 WRITE (6,830)                                                      STAR1256
     WRITE (6,835)(ST(N),N=1,7)                                         STAR1257
     WRITE (6,1135)NOP                                                  STAR1258
1135 FORMAT(1H0,T20,'TANK BOTTOM PRESSURE VALUES FOR',I3,' ENGINE OPERASTAR1259
    1TION PER MAIN FEED LINE')                                          STAR1260
     WRITE (6,845)(OPD(K),K=NELP,NMA)                                   STAR1261
     WRITE (6,850)                                                      STAR1262
     DO 1145 N=1,NPTS                                                   STAR1263
     WRITE (6,855)TIMEA(N)                                              STAR1264
     IF (N.EQ.NPTS) GO TO 1140                                          STAR1265
     WRITE (6,1015)(PTKBTO(I,N),I=NELP,NMA)                             STAR1266
1140 CONTINUE                                                           STAR1267
```

Fig. B-1 STAR Program Listing (Cont'd)

```
1268,    1145 CONTINUE                                                    STAR1268
1269,    1150 CONTINUE                                                    STAR1269
1270,         IF (SYSNUM.EQ.1) GO TO 1165                                 STAR1270
1271,         WRITE (6,830)                                               STAR1271
1272,         WRITE (6,880)(ST(N),N=1,7)                                  STAR1272
1273,         WRITE (6,1135)NOP                                           STAR1273
1274,         WRITE (6,845)(HPD(K),K=NELP,NMA)                            STAR1274
1275,         WRITE (6,850)                                               STAR1275
1276,         DO 1160 N=1,NPTS                                            STAR1276
1277,         WRITE (6,855)TIMEA(N)                                       STAR1277
1278,         IF (N.EQ.NPTS) GO TO 1155                                   STAR1278
1279,         WRITE (6,1015)(PTKBTW(I,N),I=NELP,NMA)                      STAR1279
1280,    1155 CONTINUE                                                    STAR1280
1281,    1160 CONTINUE                                                    STAR1281
1282,    1165 CONTINUE                                                    STAR1282
1283,    C                                                                STAR1283
1284,    C      WRITE OUT RECOMPUTED ENGINE PRESSURES                     STAR1284
1285,    C                                                                STAR1285
1286,         GO TO (1170,1190,1170),SYSNUM                               STAR1286
1287,    1170 WRITE (6,830)                                               STAR1287
1288,         WRITE (6,835)(ST(N),N=1,7)                                  STAR1288
1289,         WRITE (6,1175)NOP                                           STAR1289
1290,    1175 FORMAT(1H0,T20,'RECOMPUTED ENGINE PRESSURES FOR',I3,' ENGINE OPERASTAR1290
1291,        1TION PER MAIN FEED LINE')                                  STAR1291
1292,         WRITE (6,845)(HPD(K),K=NELP,NMA)                            STAR1292
1293,         WRITE (6,850)                                               STAR1293
1294,         DO 1165 N=1,NPTS                                            STAR1294
1295,         WRITE (6,855)TIMEA(N)                                       STAR1295
1296,         IF (N.EQ.NPTS) GO TO 1180                                   STAR1296
1297,         WRITE (6,1015)(PENNUO(I,N),I=NELP,NMA)                      STAR1297
1298,    1180 CONTINUE                                                    STAR1298
1299,    1185 CONTINUE                                                    STAR1299
1300,    1190 CONTINUE                                                    STAR1300
1301,         IF (SYSNUM.EQ.1) GO TO 1205                                 STAR1301
1302,         WRITE (6,830)                                               STAR1302
1303,         WRITE (6,880)(ST(N),N=1,7)                                  STAR1303
1304,         WRITE (6,1175)NOP                                           STAR1304
1305,         WRITE (6,845)(HPD(K),K=NELP,NMA)                            STAR1305
1306,         WRITE (6,850)                                               STAR1306
1307,         DO 1200 N=1,NPTS                                            STAR1307
1308,         WRITE (6,855)TIMEA(N)                                       STAR1308
1309,         IF (N.EQ.NPTS) GO TO 1195                                   STAR1309
1310,         WRITE (6,1015)(PENNUM(I,N),I=NELP,NMA)                      STAR1310
1311,    1195 CONTINUE                                                    STAR1311
1312,    1200 CONTINUE                                                    STAR1312
1313,    1205 CONTINUE                                                    STAR1313
1314,    C                                                                STAR1314
1315,    C      WRITE OUT FEED SYSTEM WEIGHTS                             STAR1315
1316,    C                                                                STAR1316
1317,         WRITE (6,830)                                               STAR1317
1318,         WRITE (6,1210)(ST(I),I=1,7)                                 STAR1318
1319,    1210 FORMAT(T23,7A6,T66,'- FEED SYSTEM WEIGHTS',//T16,'MAIN',T30,'ENGINSTAR1319
1320,        1E FEEDLINE WEIGHTS',T65,'TOTAL',T85,'ENGINE',T97,'MAIN',/T14,'FEEDSTAR1320
1321,        2LINE',T64,'ENGINE     MAIN     FEEDLINE     FEEDLINE      TOTAL',/ STAR1321
1322,        3T2,'PROPELLANT  DIAMETER',T26,'LINE',T36,'LINE',T46,'LINE',T56,   STAR1322
1323,        4'LINE',T63,'FEEDLINE  FEEDLINE   INSULATION  INSULATION  FEED SYSTSTAR1323
1324,        5EM',/T14,'(INCHES)',T26,'NO 1',T36,'NO 2',T46,'NO3',T56,'NO 4',   STAR1324
1325,        6T63,'WEIGHT',T74,'WEIGHT',T85,'WEIGHT',T97,'WEIGHT',T110,'WEIGHT')STAR1325
```

Fig. B-1 STAR Program Listing (Cont'd)

```
1326.          WRITE (6,665)                                                    STAR1326
1327.          IF (SYSNUM.EQ.2) GO TO 1220                                      STAR1327
1328.          DO 1215 I=NELP,NSIZE                                             STAR1328
1329.          WRITE (6,1230)O2(1),O2(2),OPD(I),(WELO(I,J),J=1,4),WELOT(I),WMLO(ISTAR1329
1330.         1),WELIOT(I),WM_IO(I),WLOTT(I)                                    STAR1330
1331.     1215 CONTINUE                                                         STAR1331
1332.          WRITE (6,665)                                                    STAR1332
1333.     1220 DO 1225 I=NELP,NSIZE                                             STAR1333
1334.          WRITE (6,1230)H2(1),H2(2),HPD(I),(WELH(I,J),J=1,4),WELHT(I),WMLH(ISTAR1334
1335.         1),WELIHT(I),WM_IH(I),WLHTT(I)                                    STAR1335
1336.     1225 CONTINUE                                                         STAR1336
1337.     1230 FORMAT(T2,2A6,F7.3,2X,6G10.5,3X,G10.5,2X,G10.5,3X,G10.5)         STAR1337
1338.          WRITE (6,665)                                                    STAR1338
1339.          WRITE (6,1235)ICASE                                              STAR1339
1340.     1235 FORMAT(T10,'END OF CASE',I3)                                     STAR1340
1341.     C                                                                     STAR1341
1342.          IF (IGOON.EQ.1) GO TO 10                                         STAR1342
1343.     C                                                                     STAR1343
1344.          CONTINUE                                                         STAR1344
1345.          WRITE (6,830)                                                    STAR1345
1346.          WRITE (6,1245)                                                   STAR1346
1347.     1245 FORMAT(T5,'***  NORMAL PROGRAM TERMINATION HAS OCCURRED  ***')   STAR1347
1348.          CALL EXIT                                                        STAR1348
1349.          END                                                              STAR1349
```

Fig. B-1 STAR Program Listing (Cont'd)

```
      C                                                                  INIV0001
      SUBROUTINE INIVOL                                                  INIV0002
      C                                                                  INIV0003
      INCLUDE  DIMN,LIST                                                 INIV0004
      C                                                                  INIV0005
      C                  CALCULATE TOTAL VOLUME                          INIV0006
      C                  LO2 SECTION                                     INIV0007
      C                  VOLUME OF UPPER (SMALL) HEMISPHERE SECTION      INIV0008
            V1 = HSPHER (R1,R2)                                          INIV0009
            A1 = ARSPHR (R1,R2)                                          INIV0010
      C                  VOLUME OF CONIC SECTION                         INIV0011
            V2 = FRCONE (R2,L2-L1,R4)                                    INIV0012
            A2 = AREAFR (R2,L2-L1,R4)                                    INIV0013
      C                  VOLUME OF CYLINDRICAL SECTION                   INIV0014
            V3 = CYLNDR (R4,L3-L2)                                       INIV0015
            A3 = ARACYL (R4,L3-L2)                                       INIV0016
      C                  VOLUME OF LOWER (LARGE) HEMISPHERICAL SECTION (LO2) INIV0017
            V4 = HSPHER (R3,R4)                                          INIV0018
            A4 = ARSPHR (R3,R4)                                          INIV0019
      C                  LH2 SECTION                                     INIV0020
      C                  VOLUME BETWEEN CYLINDER AND SPHEROID            INIV0021
            V5 = CYLSPH (R3,R4)                                          INIV0022
      C                  VOLUME OF LONG CYLINDRICAL SECTION              INIV0023
            V6 = CYLNDR (R4,L4-L3-R3)                                    INIV0024
            A6 = ARACYL (R4,L4-L3)                                       INIV0025
      C                  VOLUME OF LOWER (LARGE) HEMISPHERICAL SECTION (LH2) INIV0026
            V7 = HSPHER (R5,R4)                                          INIV0027
            A7 = ARSPHR (R5,R4)                                          INIV0028
      C                  TOTAL VOLUME OF UPPER PORTION (LO2)             INIV0029
            VTO2 = V1+V2+V3+V4                                           INIV0030
      C                  TOTAL VOLUME OF LOWER PORTION (LH2)             INIV0031
            VTH2 = V5 + V6 + V7                                          INIV0032
      C                  TOTAL VOLUME BOTH SECTIONS                      INIV0033
            VTOT = VTO2+VTH2                                             INIV0034
            ATOT = A1 + A2 + A3 + A4 + A6 + A7                           INIV0035
            ASKIN = ATOT - A4                                            INIV0036
            ADOME = A4                                                   INIV0037
            RETURN                                                       INIV0038
            END                                                          INIV0039
```

Fig. B-2 INIVOL Program Listing

```
      C                                                                 ULLH0001
      SUBROUTINE ULLHED (VLO2,VLH2)                                     ULLH0002
      C                                                                 ULLH0003
      INCLUDE  DIMN,LIST                                                ULLH0004
      INCLUDE  UCONST,LIST                                              ULLH0005
      C                                                                 ULLH0006
   10 FORMAT ('0',20X,'ULLAGE VOLUME IS NEGATIVE'/)                     ULLH0007
      C ---------------------------------------------------------------- ULLH0008
      C                  CALCULATE HEAD AND ULLAGE VOLUME               ULLH0009
      C                  ULLAGE VOLUME  (LO2)                           ULLH0010
      UVLO2 = VTO2-VLO2                                                 ULLH0011
      IF (UVLO2.LT.0.) WRITE (IOT,10)                                   ULLH0012
      C                  CALCULATE HEAD (LO2)                           ULLH0013
      C                  LARGE HEMISPHERE                               ULLH0014
      IF (VLO2-V4) 15,20,20                                             ULLH0015
   15 CALL ELIPSG (VLO2,R3,R4,HDO2)                                     ULLH0016
      GO TO 45                                                          ULLH0017
      C                  CYLINDRICAL SECTION                            ULLH0018
   20 IF (VLO2-(V4+V3)) 25,25,30                                        ULLH0019
   25 HDO2 = R3 + (VLO2-V4) / (PI*R4*R4)                                ULLH0020
      GO TO 45                                                          ULLH0021
      C                  CONIC SECTION                                  ULLH0022
   30 IF (VLO2-(V4+V3+V2)) 35,35,40                                     ULLH0023
   35 HL = L2 - L1                                                      ULLH0024
      R42 = R4 - R2                                                     ULLH0025
      VD = (PI/3.0)*HL / R42*R4*R4*R4 - (VLO2-V4-V3)                    ULLH0026
      HDO2 = (PI*R4*HL - (3.0*(PI*HL)**2*R42*VD)**(1./3.)) / (PI*R42)   ULLH0027
      HDO2 = R3 + L3 - L2 + HDO2                                        ULLH0028
      GO TO 45                                                          ULLH0029
      C                  SMALL HEMISPHERE                               ULLH0030
   40 CALL ELIPSG (UVLO2,R1,R2,H)                                       ULLH0031
      HDO2 = R3 + L3-L1 + R1-H                                          ULLH0032
      C                  ULLAGE VOLUME  (LH2)                           ULLH0033
   45 UVLH2 = VT42 - VLH2                                               ULLH0034
      IF (UVLH2.LT.0.) WRITE (IOT,10)                                   ULLH0035
      C                  CALCULATE HEAD (LH2)                           ULLH0036
      C                  LOWER HEMISPHERICAL SECTION                    ULLH0037
      IF (VLH2-V7) 50,55,55                                             ULLH0038
   50 CALL ELIPSG (VLH2,R5,R4,HDH2)                                     ULLH0039
      GO TO 70                                                          ULLH0040
   55 IF (VLH2-(V7+V6)) 60,60,65                                        ULLH0041
      C                  CYLINDRICAL SECTION                            ULLH0042
   60 HDH2 = R5 + (VLH2 - V7) / (PI*R4*R4)                              ULLH0043
      GO TO 70                                                          ULLH0044
      C                  SECTION BETWEEN CYLINDER AND SPHEROID          ULLH0045
   65 VHP = VLH2 - (V7+V6)                                              ULLH0046
      CALL CYMSPH (VHP,R3,R4,H)                                         ULLH0047
      HDH2 = R5 + L4 - (L3+R3) + H                                      ULLH0048
   70 CONTINUE                                                          ULLH0049
      RETURN                                                            ULLH0050
      END                                                               ULLH0051
```

Fig. B-3 ULLHED Program Listing

```
      SUBROUTINE FLORES(ID,D,S1,S2,RES)                                  FLOR0001
C                                                                        FLOR0002
C     THIS SUBROUTINE COMPUTES ONLY THE FLOW RESISTANCE COEFFICIENTS     FLOR0003
C     DUE TO CONFIGURATION - FRICTION LOSSES ARE COMPUTED IN MAIN PROGRA FLOR0004
      PI=3.1415927                                                       FLOR0005
      C=57.29578                                                         FLOR0006
      P=D/12.                                                            FLOR0007
      GO TO (10,15,20,40,45,60,65,85,100,110,115,125,135,140,145,150,145 FLOR0008
     1,155,155,160,165,135,145),ID                                       FLOR0009
C     SUMP                                                               FLOR0010
   10 RES=0.157                                                          FLOR0011
      RETURN                                                             FLOR0012
C     STRAIGHT LINE SECTION                                              FLOR0013
   15 RES=0.                                                             FLOR0014
      RETURN                                                             FLOR0015
C     CURVED LINE SECTION                                                FLOR0016
   20 THETA=(S1/S2)*C                                                    FLOR0017
      TEST=THETA-90.                                                     FLOR0018
      RES90=0.158*(S2/P)**(-0.8406)                                      FLOR0019
      IF (ABS(TEST).GT.1.) GO TO 25                                      FLOR0020
      RES=RES90                                                          FLOR0021
      RETURN                                                             FLOR0022
   25 IF (TEST.LT.0.) GO TO 30                                           FLOR0023
      RES=0.145*RES90*THETA**0.431                                       FLOR0024
      RETURN                                                             FLOR0025
   30 IF (THETA.LT.60.) GO TO 35                                         FLOR0026
      RES=RES90*0.0147*THETA**0.616                                      FLOR0027
      RETURN                                                             FLOR0028
   35 RES=RES90*0.0047*THETA**0.793                                      FLOR0029
      RETURN                                                             FLOR0030
C     COMPOUND 'U' ELBOW (LENGHT STRAIGHT SECTION LT 8*D)                FLOR0031
   40 SL=S1-PI*S2                                                        FLOR0032
      RES=0.2153*(S2/P)**(-0.8406)                                       FLOR0033
      RES=RES+0.02*(SL/P)                                                FLOR0034
      RETURN                                                             FLOR0035
C     NINETY-DEGREE OFFSET BEND                                          FLOR0036
   45 SL=S1-PI*S2                                                        FLOR0037
      RESLD0=0.248*(S2/P)**(-1.307)                                      FLOR0038
      RESLD8=0.322*(S2/P)**(-1.025)                                      FLOR0039
   50 BLOD=SL/P                                                          FLOR0040
      IF (BLOD.LT.8.) GO TO 55                                           FLOR0041
      RES=RESLD8                                                         FLOR0042
      RETURN                                                             FLOR0043
   55 DIF=RESLD8-RESLD0                                                  FLOR0044
      DIFL=BLOD/8.                                                       FLOR0045
      RES=RESLD0+DIF*DIFL                                                FLOR0046
      RETURN                                                             FLOR0047
C     'Z'-BEND                                                           FLOR0048
   60 SL=S1-PI*S2                                                        FLOR0049
      RESLD0=0.48*(S2/P)**(-1.128)                                       FLOR0050
      RESLD8=0.332*(S2/P)**(-1.022)                                      FLOR0051
      GO TO 50                                                           FLOR0052
C     GRADUAL EXPANSION                                                  FLOR0053
```

Fig. B-4 FLORES Program Listing

```
54.       65 RES=(1.-S2**2.)**2.                                          FLOR0054
55.          D=D/12.                                                      FLOR0055
56.          ARG=P*(1./S2-1.)/(2.*S1)                                     FLOR0056
57.          THETA=C*ATAN(ARG)                                            FLOR0057
58.          IF (THETA.GT.5.) GO TO 70                                    FLOR0058
59.          CK=0.013*THETA                                               FLOR0059
60.          GO TO 80                                                     FLOR0060
61.       70 IF (THETA.GT.24.) GO TO 75                                   FLOR0061
62.          CK=0.065+0.0513*(THETA-5.)                                   FLOR0062
63.          GO TO 80                                                     FLOR0063
64.       75 CK=1.0*4                                                     FLOR0064
65.       80 RES=CK*RES                                                   FLOR0065
66.          RETURN                                                       FLOR0066
67.    C     GRADUAL CONTRACTION                                          FLOR0067
68.       85 ARG=D*(1.-1./S2)/(24.*S1)                                    FLOR0068
69.          THETA=C*ATAN(ARG)                                            FLOR0069
70.          IF (THETA.GT.15.) GO TO 90                                   FLOR0070
71.          RES=0.                                                       FLOR0071
72.          RETURN                                                       FLOR0072
73.       90 IF (THETA.GT.22.5) GO TO 95                                  FLOR0073
74.          RES=0.05                                                     FLOR0074
75.          RETURN                                                       FLOR0075
76.       95 RES=(1.-S2**2.)**2.                                          FLOR0076
77.          RETURN                                                       FLOR0077
78.    C     SINGLE LEG OF DIVERGING BRANCH                               FLOR0078
79.      100 WRITE (6,105)                                                FLOR0079
80.      105 FORMAT(T2,'S/R FLORES - DIVERGING BRANCH OPTION NOT IMPLEMENTED') FLOR0080
81.          RES=0.                                                       FLOR0081
82.          RETURN                                                       FLOR0082
83.    C     VENTURI                                                      FLOR0083
84.      110 S1=S1/2.                                                     FLOR0084
85.          GO TO 65                                                     FLOR0085
86.    C     FLOWMETER                                                    FLOR0086
87.      115 WRITE (6,120)                                                FLOR0087
88.      120 FORMAT(T2,'S/R FLORES - FLOWMETER OPTION NOT IMPLEMENTED')   FLOR0088
89.          RES=0.                                                       FLOR0089
90.          RETURN                                                       FLOR0090
91.    C     GATE VALVE                                                   FLOR0091
92.      125 WRITE (6,130)                                                FLOR0092
93.      130 FORMAT(T2,'S/R FLORES - GATE VALVE OPTION NOT IMPLEMENTED')  FLOR0093
94.          RES=0.                                                       FLOR0094
95.          RETURN                                                       FLOR0095
96.    C     BUTTERFLY VALVE OR PRESSURE-VOLUME COMPENSATOR               FLOR0096
97.      135 RES=0.94*D**(-0.676)                                         FLOR0097
98.          RETURN                                                       FLOR0098
99.    C     POPPET VALVE                                                 FLOR0099
100.     140 RES=4.9*D**(-0.599)                                          FLOR0100
101.         RETURN                                                       FLOR0101
102.   C     BALL VISOR VALVE, U-PIN TIE ROD BELLOWS OR INTERNAL BALL-STRUT BELFLOR0102
103.     145 RES=0.325*D**(-0.292)                                        FLOR0103
104.         RETURN                                                       FLOR0104
105.   C     DISCONNECT                                                   FLOR0105
106.     150 RES=0.3                                                      FLOR0106
107.         RETURN                                                       FLOR0107
108.   C     PIN OR HINGE JOINT BELLOWS OR EXT. GIMBAL BELLOWS W/O LINER  FLOR0108
109.     155 RES=0.23*D**(-0.607)                                         FLOR0109
110.         RETURN                                                       FLOR0110
111.   C     EXT. GIMBAL BELLOWS WITH LINER                               FLOR0111
```

Fig. B-4 FLORES Program Listing (Cont'd)

```
      160 RES=0,079*J**(-0,594)                                          FLOR0112
          RETURN                                                         FLOR0113
C         INTERNAL GIMBAL BELLOWS W/O LINER                              FLOR0114
      165 RES=0,111*J*(=0,55)                                            FLOR0115
          RETURN                                                         FLOR0116
          END                                                            FLOR0117
```

Fig. B-4 FLORES Program Listing (Cont'd)

```
      SUBROUTINE PVAPOR(T,I,P)                                          PVAP0001
      GO TO (10,15,20,15,25,30,35,30,35,40,20,45,50,55,60,65),I         PVAP0002
   10 P=EXP(12,04-1519,/T)                                              PVAP0003
      RETURN                                                            PVAP0004
   15 P=10,**(2,9303-79,821/T+,011628*T)                                PVAP0005
      RETURN                                                            PVAP0006
   20 P = EXP(11,63-1374,/T)                                            PVAP0007
      IF(P,GT,200,) P = EXP(13,43-1763,/T)                              PVAP0008
      RETURN                                                            PVAP0009
   25 P = ,825*EXP(11,63-1374,/T)+,175*EXP(12,04-1519,/T)               PVAP0010
      IF(P,GT,200,) P = ,825*EXP(13,43-1763,/T)+,175*EXP(12,04-1519,/T)PVAP0011
      RETURN                                                            PVAP0012
   30 P = EXP(11,83-1839,/T)                                            PVAP0013
      RETURN                                                            PVAP0014
   35 P = 10,**(5,73-1050,/T)                                           PVAP0015
      RETURN                                                            PVAP0016
   40 P = EXP(12,3579-3168,7/T)                                         PVAP0017
      RETURN                                                            PVAP0018
   45 P = EXP(14,45-5090,/T)                                            PVAP0019
      RETURN                                                            PVAP0020
   50 P = EXP(16,54098-7,3483*(1000,/T))                                PVAP0021
      RETURN                                                            PVAP0022
   55 P = EXP(13,4055-6,65*(1000,/T))                                   PVAP0023
      RETURN                                                            PVAP0024
   60 PLOGMM = 7,4837-1,8*1197,/T                                       PVAP0025
      P = ,01934*(10,**PLOGMM)                                          PVAP0026
      RETURN                                                            PVAP0027
   65 PLOGMM = 8,2875-1,8*1996,/T                                       PVAP0028
      P = ,01934*(10,**PLOGMM)                                          PVAP0029
      RETURN                                                            PVAP0030
      END                                                               PVAP0031
```

Fig. B-5 PVAPOR Program Listing

```
      SUBROUTINE ZFIND(T,P,N,V)                                          ZFIN0001
      DIMENSION G(3,17),S(17)                                            ZFIN0002
      DIMENSION A(17,6),TS(17)                                           ZFIN0003
      DATA (TS(K),K=1,16)                                                ZFIN0004
     1         /150.,  30.,  140.,  30.,140.,190.,220.,190.,             ZFIN0005
     2          220.,300.,140.,370.,475.,480.,450.,450./                 ZFIN0006
      DATA(G(1,I),I=1,17)/277.85,59.8,259.13,59.8,260.,343.2,387.,343.2ZFIN0007
     1,387.,521.8,259.13,730.,776.4,1094.,749.5,1155.,9.37/             ZFIN0008
      DATA(G(2,I),I=1,17)/743.78,187.7,822.8,187.7,795.,673.1,719.,673.ZFIN0009
     1 1,719.,581.,822.8,1652.,1470.,1696.,771.,1470.,33.82/            ZFIN0010
      DATA(G(3,I),I=1,17)/48.31,766.8,40.67,766.8,42.01,96.35,28.62.     ZFIN0011
     1  96.35,28.62,55.81,40.67,90.77,16.78,37.0.11,90.33,50.386.3/      ZFIN0012
      DATA S/5HLO2  ,5HLH2  ,5HLF2  ,5HLH2  ,5HFLOX ,5HCH4  ,5HOF2  ,   ZFIN0013
     1        5HCH4  ,5HOF2  ,5HB2H6 ,5HLF2  ,5HNH3  ,5HN204 ,5HA-50 ,   ZFIN0014
     2        5HCLF-5,5HMMHF-5,5HHE   /                                  ZFIN0015
      DATA(A( 1,J),J=1,6)/.2142592E1,-.3228322E-1,.3563987E-3,           ZFIN0016
     1 -.1895669E-5,.4823166E-8,-.5002793E-11/                           ZFIN0017
      DATA(A( 2,J),J=1,6)/-.4458459E1,.6350202,-.2863016E-1,             ZFIN0018
     1 .6260532E-3,-.6704223E-5,.2763409E-7/                             ZFIN0019
      DATA(A( 3,J),J=1,6)/.1920920JE1,-.4596045E-1,.7505833E-3,          ZFIN0020
     1 -.5522453E-5,.1900218E-7,-.2526448E-10/                           ZFIN0021
      DATA(A( 4,J),J=1,6)/-.4458459E1,.6350202,-.2863016E-1,             ZFIN0022
     1 .6260532E-3,-.6704223E-5,.2763409E-7/                             ZFIN0023
      DATA(A( 5,J),J=1,6)/.1847661JE1,-.4146008E-1,.6702877E-3,          ZFIN0024
     1 -.4895455E-5,.1674002E-7,-.2217407E-10/                           ZFIN0025
      DATA(A( 6,J),J=1,6)/.1700580JE1,-.1669025E-1,.1536145E-3,          ZFIN0026
     1 -.6691577E-6,.1360997ZE-8,-.1135781JE-11/                         ZFIN0027
      DATA(A( 7,J),J=1,6)/.1521982JE2,-.2801246J,.2200102JE-2,           ZFIN0028
     1 -.8611922GE-5,.1683533JE-7,-.1326416E-10    /                     ZFIN0029
      DATA(A( 8,J),J=1,6)/.1700580JE1,-.1669025E-1,.1536145E-3,          ZFIN0030
     1 -.6691577E-6,.1360997ZE-8,-.1135781JE-11/                         ZFIN0031
      DATA(A( 9,J),J=1,6)/.1521982JE2,-.2801246J,.2200102JE-2,           ZFIN0032
     1 -.8611922GE-5,.1683533JE-7,-.1326416E-10    /                     ZFIN0033
      DATA(A(10,J),J=1,6)/-.8144980JE-1,.1560483GE-1,-.9195427JE-4,      ZFIN0034
     1 .2781398JE-6,-.4273969ZE-9,.2517051ZE-12/                         ZFIN0035
      DATA(A(11,J),J=1,6)/.1920920JE1,-.4596045E-1,.7505833E-3,          ZFIN0036
     1 -.5522453E-5,.1900218E-7,-.2526448E-10/                           ZFIN0037
      DATA(A(12,J),J=1,6)/.3923331JE1,-.3459529JE-1,.1630650JE-3,        ZFIN0038
     1-.3845243ZE-6,.4557279ZE-9,-.2197985JE-12/                         ZFIN0039
      DATA(A(13,J),J=1,6)/.7012230JE1,-.5741309JE-1,.2196749JE-3,        ZFIN0040
     1 -.4219872JE-6,.4086498JE-9,-.1606916E-12/                         ZFIN0041
      DATA(A(14,J),J=1,6)/.8640584JE1,-.7217616JE-1,.2724231E-3,         ZFIN0042
     1 -.5137489E-6,.4844758E-9,-.1830806ZE-12/                          ZFIN0043
      DATA(A(15,J),J=1,6)/.5485883JE1,-.4480628JE-1,.1778949ZE-3,        ZFIN0044
     1 -.3508955BE-6,.3453972GE-9,-.1303201GE-12/                        ZFIN0045
      DATA(A(16,J),J=1,6)/.4940754JE1,-.3964995JE-1,.1595564BE-3,        ZFIN0046
     1 -.3211566JE-6,.3235670E-9,-.1306815GE-12/                         ZFIN0047
      IF (N.EQ.17) GO TO 10                                              ZFIN0048
      IF (T.GT.650..OR.T.LT.25.) GO TO 55                                ZFIN0049
      IF (T.GT.TS(N)+100..OR.T.LT.TS(N)) GO TO 10                        ZFIN0050
C**** TEST TO SEE IF SAT.D COMP.Y Z APPLIES ************************** ZFIN0051
      CALL PVAPOR(T,N,TRYP)                                              ZFIN0052
      TRY=TRYP-P                                                         ZFIN0053
```

Fig. B-6 ZFIND Program Listing

```
      IF (ABS(TRY).LT.5.) GO TO 60                                      ZFIN0054
   10 CONTINUE                                                          ZFIN0055
C*************************REDLICH-KWONG*****************AGO-GO******ZFIN0056
      VF=G(3,N)*T/(P*144.)                                              ZFIN0057
      IF (N.EQ.2.OR.N.EQ.4) GO TO 45                                    ZFIN0058
      AS=.4278*G(3,N)*G(3,N)/(G(2,N)*144.)*G(1,N)**2.5                  ZFIN0059
      BS=.0867*G(3,N)*G(1,N)/(G(2,N)*144.)                              ZFIN0060
      IN=0                                                              ZFIN0061
      N2=0                                                              ZFIN0062
      E=.00001                                                          ZFIN0063
      V=VF                                                              ZFIN0064
   15 Y=G(3,N)*T/(V-BS)-AS/(T**.5*V*(V+BS))-P*144.                      ZFIN0065
      IF (ABS(Y).LT.E) GO TO 30                                         ZFIN0066
C*************************FIRST DERIVITIVE OF REDLICH-KWONG RESPECT TZFIN0067
      YP=-G(3,N)                                                        ZFIN0068
     1      *T/((V-BS)*(V-BS))+AS*(2.*V+BS)/(T**.5*V*V*(V+BS)*(V+BS))   ZFIN0069
      IN=IN+1                                                           ZFIN0070
      N2=N2+1                                                           ZFIN0071
      IF(N2.EQ.25) E=2.*E                                               ZFIN0072
      IF(N2.EQ.25) N2=0                                                 ZFIN0073
      IF (IN.GT.1000) GO TO 35                                          ZFIN0074
      V=V-Y/YP                                                          ZFIN0075
      IF (V.GT.0.) GO TO 25                                             ZFIN0076
        OLDV=V+Y/YP                                                     ZFIN0077
      DELTA=Y/YP                                                        ZFIN0078
      FACTOR=.05                                                        ZFIN0079
   20 V=OLDV-FACTOR*DELTA                                               ZFIN0080
      FACTOR=FACTOR*.9                                                  ZFIN0081
      IF (V.LT.0.) GO TO 20                                             ZFIN0082
   25 CONTINUE                                                          ZFIN0083
      GO TO 15                                                          ZFIN0084
   30 CONTINUE                                                          ZFIN0085
      GO TO 50                                                          ZFIN0086
   35 CONTINUE                                                          ZFIN0087
      WRITE (6,40)T,P,S(N),V,VF                                         ZFIN0088
   40 FORMAT(1X,34HREDLICH - KWONG      FLUNKED  T = ,F4.2,2X,4HP = ,   ZFIN0089
     1  F7.2,                                                          ZFIN0090
     2  5H FOR ,A5,2X,4HV = ,E10.5,2X,8HRETURNED,E10.5)                ZFIN0091
      V=VF                                                              ZFIN0092
      GO TO 50                                                          ZFIN0093
   45 TT=T+0.5                                                          ZFIN0094
      V=PTDENS(P      ,TT)                                              ZFIN0095
      V=1./V                                                            ZFIN0096
   50 V=V/VF                                                            ZFIN0097
      RETURN                                                            ZFIN0098
   55 V=1.                                                              ZFIN0099
      RETURN                                                            ZFIN0100
   60 CONTINUE                                                          ZFIN0101
      V=A(N,1)+A(N,2)*T+A(N,3)*T*T+A(N,4)*T*T*T+A(N,5)*T**4+A(N,6)*T**5ZFIN0102
      RETURN                                                            ZFIN0103
      END                                                               ZFIN0104
```

Fig. B-6 ZFIND Program Listing (Cont'd)

```
1,          FUNCTION FINDR(N)                                                    FIND0001
2,          DIMENSION G(17)                                                      FIND0002
3,          DATA    G  / 48,31,766,8,40,67,766,8,42,01,96,35,28,62,96,35,28,62,FIND0003
4,         155,81,40,67,90,77,16,78,37,0,11,90,33,90,306,3/                      FIND0004
5,          FINDR=G(N)                                                           FIND0005
6,          RETURN                                                               FIND0006
7,          END                                                                  FIND0007
```

Fig. B-7 FINDR Program Listing

```
      FUNCTION PTDENS(PRES,TEMP)                                        PTDE0001
      DIMENSION PS(20),TS(20),JP(28),MX(28),LOC(30),BP(28),DP(28),BT(30)PTDE0002
     1,DT(28),R(886)                                                    PTDE0003
      DIMENSION AA(109),AB( 97),AC(108),AD(106),AE(106),AF(108),AG(101) PTDE0004
     1 ,AH(111),AI( 41)                                                 PTDE0005
      EQUIVALENCE( R,AA),( R( 110),AB),( R( 207),AC),( R( 315),AD)      PTDE0006
     1    ,( R( 421),AE),( R( 527),AF),( R( 635),AG),( R( 736),AH)      PTDE0007
     2    ,( R( 847),AI)                                                PTDE0008
      DATA PS/1,022,2,,4,,8,,14,,25,,43,,69,,99,,128,,151,,165,,176,,   PTDE0009
     1162,,185,,186,5,187,25,187,46875,187,506,187,6385/                PTDE0010
      DATA TS/24,845,27,07,29,81,33,07,36,18,39,96,44,12,48,33,51,97,54,PTDE0011
     179,56,72,57,80,50,57,58,99,59,18,59,29,59,34,59,353,59,356,59,4/  PTDE0012
      DATA LOC/1,23,78,105,141,155,183,201,225,240,267,321,341,377,401, PTDE0013
     1 425,437,453,469,494,534,546,586,682,722,782,800,848,866,878/     PTDE0014
      DATA JP/2,5,3,4,2,4,3,4,3,3,3,4,4,4,3,3,4,4,5,8,4,5,12,5,3,6,6,6/ PTDE0015
      DATA MX/0,3,1,2,0,2,1,2,1,1,1,2,2,2,1,1,2,2,3,6,2,3,10,3,1,4,4,4/ PTDE0016
      DATA BP/0,,200,,-100,, 0,,0,,0,,-4,,0,,2645,28,1469,6,881,76,0,,0,PTDE0017
     1,-44,088,587,84,293,92,73,48,-14,696,293,92,36,74,-7,348,293,92,  PTDE0018
     2180,,0,,0,,29,392,102,872,29,392/                                 PTDE0019
      DATA DP/800,,1200,0,200,0,1000,0,100,0,1000,0,7,0,1000,0,1175,68, PTDE0020
     1 587,64,293,92,293,92,293,92,58,784,146,96,146,96,73,48,29,392,   PTDE0021
     2 73,48,36,74,14,696,73,48,10,0,7,348,1,4695,14,696,14,696,29,392/ PTDE0022
      DATA BT/180,0,180,0,500,0,500,0,1300,0,1300,0,2500,0,2500,0,36,0, PTDE0023
     1 36,0,27,0,27,0,108,0,108,0,57,6,86,4,46,4,86,4,72,0,72,0,72,0,  PTDE0024
     2 59,4,59,4,30,0,23,4,39,6,52,2,64,8,5000,,5000,/                  PTDE0025
      DATA DT/30,0,30,0,100,0,100,0,200,0,200,0,300,0,500,0,36,0,18,0,  PTDE0026
     1 9,0,9,0,9,0,14,4,7,2,7,2,7,2,7,2,3,6,3,6,,2,1,8,1,8,6,0,5,4,3,6,PTDE0027
     2 1,8,3,6/                                                         PTDE0028
      DATAAA/0,,,8376,0,,,7052,0,,,6114,0,,,5412,0,,,4862,0,,,4419,0,,,4PTDE0029
     1053,0,,,3746,0,,,3483,0,,,3255,0,,,3056,,2652,1,41,2,315,2,924,3,3PTDE0030
     1296,,2314,1,179,1,979,2,584,3,052,,1998,1,023,1,739,2,309,2,765,,17PTDE0031
     1366,,9058,1,554,2,087,2,526,,1577,,8147,1,407,1,905,2,325,,1424,,74PTDE0032
     1414,1,286,1,754,2,154,,1297,,6809,1,186,1,626,2,008,,1192,,63,1,102PTDE0033
     15,1,516,1,881,,1101,,5865,1,029,1,421,1,769,,1021,,5489,,9656,1,338PTDE0034
     16,1,671,,0953,,5159,,91,1,264,1,584,-,03747,,03747,,1114,-,03125,,0PTDE0035
     173125,,09302,-,02679,,02679,,07985,-,02345,,02345,,06995,-,02085,,0PTDE0036
     182085,,06224,-,01877,,01877,,05606,-,01706,,01706,,05099,-,01565,,0PTDE0037
     191565,,04677,-,01445,,01445,,04282,,00464,,3605,,6912,,9949,,00341/PTDE0038
      DATAAB/,3021,,5825,,8432,,0026,,2601,,5038,,7325,,002,,2285,,4441,PTDE0039
     1,6479,,00161,,2037,,3972,,581,,00131,,1838,,3592,,5267,,0011,,1674PTDE0040
     2,,3279,,4818,,0009,,1538,,3017,,4439,,00027,,1422,,2793,,4116,0,,,PTDE0041
     301445,0,,,01252,0,,,01105,0,,,009892,0,,,008951,0,,,008174,0,,,007PTDE0042
     44521,,000267,,1422,,2793,,4116,,000189,,1235,,2432,,3592,,000144,,1PTDE0043
     55092,,2154,,3187,,00012,,09785,,1933,,2864,9,8E-5,,08864,,1753,,260PTDE0044
     661,8,1E-5,,08101,,1604,,2382,6,9E-5,,07459,,1478,,2196,-,0003009,,0PTDE0045
     77002256,,0007521,-,000251,,0001882,,0006272,-,000215,,0001611,,0005PTDE0046
     88373,-,0001878,,0001402,,0004686,-,0001656,,0001221,,0004119,-,0001PTDE0047
     99452,,0001042,,0003599,6,9E-6,,07459,,1478,,2196,4,6E-6,,06226/   PTDE0048
      DATAAC/,1236,,1839,3,1E-6,,05342,,1061,,1582,9,E-7,,04677,,09301,,PTDE0049
     111387,-3,6E-6,,04155,,08272,,1235,-1,3E-5,,0373,,07436,,1111,5,27,PTDE0050
     125,489,5,68,4,501,4,845,5,107,3,616,4,126,4,483,2,857,3,466,3,895,2PTDE0051
     23,319,2,935,3,395,4,994,5,143,5,27,4,533,4,743,4,886,3,958,4,27,4,5PTDE0052
     3401,3,307,3,752,4,059,2,698,3,243,3,616,2,226,2,796,3,236,1,886,2,4PTDE0053
```

Fig. B-8 PTDENS Program Listing

```
      535,2.857,1.639,2.15,2.588,1.453,1.924,2.319,5.033,5.112,5.183,4.81PTDE0054
      66,4.91,4.994,4.558,4.676,4.764,4.248,4.405,4.533,3.88,4.094,4.246,PTDE0055
      73,442,3,743,3.958,2.953,3.361,3.633,2.481,2.975,3.307,2.093,2.616,PTDE0056
      83,002,1,804,2.309,2.698,1.588,2.059,2.462,1.423,1.856,2.226,1.293,PTDE0057
      91,691,2,056,1.187,1.555,1.886,1.1,1.441,1.754,1.026,1.344,1.639/  PTDE0058
       DATAAD/,9627,1.262,1.546,.9076,1.189,1.453,4.742,4.853,4.946,5.031PTDE0059
      1,4.43,4.584,4.709,4.816,4.024,4.279,4.417,4.558,3.165,3.778,4.05,4PTDE0060
      2,248,1.43,2.988,3.595,3.88,-.0233,.5581,1.189,1.804,-.015,.503,1.0PTDE0061
      35,1.588,-.0099,,4591,,945,1.423,-.0065,,4231,,8618,1.293,-.0042,,3PTDE0062
      4928,,7943,1.187,-.0025,,3669,,7379,1.1,-.0015,,3445,,6898,1.026,-,PTDE0063
      50007,,3249,,6483,,9627,-.0001,,3075,,612,,9076,-,07704,,02568,,130PTDE0064
      67,,2384,-.06785,,02262,,1144,,2079,-.00066,,02022,,1018,,1844,-,05PTDE0065
      7484,,01828,,09179,,1659,-.05004,,01668,,0836,,1508,-,04602,,01534,PTDE0066
      8,07677,,1383,3.887,3.986,4.105,3.447,3.646,3.792,2.91,3.226,3.442,PTDE0067
      92,323,2,76,3.051,1.857,2.317,2.67,1.549,1.963,2.326,1.34,1.701/   PTDE0068
       DATAAE/2.035,1.189,1.497,1.804,.7859,1.309,1.857,,6864,1.106,1.549PTDE0069
      1,,6141,,9689,1.34,,5581,,8735,1.189,,1675,,3524,,5577,,7859,,153,,PTDE0070
      23178,,4955,,6864,,1409,,2902,,4479,,6141,,1307,,2674,,4127,,5581,-PTDE0071
      3,03228,,03224,,09858,,1675,-,02974,,02971,,09043,,153,-,02756,,027PTDE0072
      454,,08359,,1409,-,02568,,02568,,07819,,1307,1,226,1,807,2,329,2,67PTDE0073
      54,2,91,1,052,1,481,1,941,2,326,2,616,,9378,1,279,1,656,2,019,2,323PTDE0074
      6,,8526,1,141,1,456,1,774,2,089,,7859,1,047,1,309,1,583,1,857,,0997PTDE0075
      75,,2084,,3279,,461,,6115,,7847,,9864,1,226,,09478,,1962,,3063,,426PTDE0076
      84,,5585,,7052,,8693,1,052,,08981,,1855,,2878,,3977,,5164,,6451,,78PTDE0077
      951,,9388,,0859,,176,,2717,,3734,,4817,,5972,,7207,,8526,,08199/   PTDE0078
       DATAAF/,1675,,2599,,3524,.455,,5577,,6718,,7859,-,01936,,01932,,05PTDE0079
      1888,,09975,-,01756,,01753,,05323,,08981,-,01615,,01611,,04882,,081PTDE0080
      299,3,304,3,422,3,541,3,659,3,777,3.044,3,29,3,45,3,572,3,667,2,74,PTDE0081
      33,102,3,304,3,449,3,557,2.322,2,88,3,141,3,315,3,447,1,861,2,621,2PTDE0082
      4,959,3,17,3,313,1,551,2,329,2,76,3,014,3,179,1,358,2,045,2,546,2,8PTDE0083
      548,3,044,1,226,1,807,2,329,2,674,2,91,,0295,2,42,2,726,2,849,2,937PTDE0084
      6,3,005,3,061,3,11,3,153,3.191,3,227,3,259,,9338,1,076,1,265,1,599,PTDE0085
      72,202,2,506,2,659,2,768,2,85,2,918,2,976,3,026,,8297,,9234,1,03,1,PTDE0086
      8159,1,322,1,542,1,035,2,136,2,356,2,509,2,618,2,709,,759,,8323,,91PTDE0087
      921,1,001,1,103,1,22,1,359,1,523,1,713,1,916,2,106,2,267,,7053/    PTDE0088
       DATAAG/,767,,8326,,9039,,9807,1,066,1,16,1,265,1,383,1,513,1,655,1PTDE0089
      1,803,,6621,,7161,,7728,,8331,,8976,,9636,1,04,1,12,1,206,1,299,1,4PTDE0090
      2,1,507,,6259,,6745,,725,,778,,8337,,8927,,9537,1,019,1,089,1,163,1PTDE0091
      3,242,1,325,,5941,,6412,,6883,,7355,,7826,,8372,,8921,,9469,1,005,1PTDE0092
      4,07,1,135,1,2,-,000743,,04849,,09854,0,,0,-,000787,,04023,,08466,PTDE0093
      5,1315,,1915,-,000437,,03393,,07032,,1097,,1534,-,000257,,02941,,06PTDE0094
      6027,,09278,,1275,-,000177,,02599,,05289,,0108,,1098,-,000122,,0233PTDE0095
      7,,0472,,07177,,09714,-8.3E-5,,02112,,04266,,06465,,08719,-6.5E-5,,PTDE0096
      801932,,0381,,05868,,07931,0,,,01172,,02363,-,000111,,009736,,0198,PTDE0097
      9-5.9E-5,,008154,,01648,-3.6E-5,,007021,,01414,-2.4E-5,,006166/    PTDE0098
       DATAAH/,0124,-1.5E-5,,005498,,01104,-1.1E-5,,004962,,009954,-9.E-6PTDE0099
      1,,004521,,009063,-7.E-6,,004153,,008321,-2.2E-5,,003846,,007715,,1PTDE0100
      2664,,248,0,,0,,0,,0,,1469,,2418,,3397,0,,0,,0,,1315,,2117,,3091,PTDE0101
      3,4233,,5318,0,,,1195,,1891,,2684,,3626,,4811,,6115,,1098,,1717,,24PTDE0102
      4,,3166,,4051,,5124,,1017,,1578,,2183,,2841,,3568,,4387,,09486,,146PTDE0103
      53,,2009,,2592,,322,,3903,,08892,,1377,,1865,,2407,,295,,3565,,5712PTDE0104
      6,,727,,9725,0,,0,,0,,,5124,,6559,,8514,1,116,0,,0,,,4755,,5827,,73PTDE0105
      729,,9604,1,252,1,718,,4387,,5333,,6477,,7994,1,068,1,534,,4145,,49PTDE0106
      856,,5914,,706,,8535,1,082,,3903,,4653,,5491,,6447,,7575,,8985,,373PTDE0107
      94,,4399,,5151,,5986,,6928,,802,,3565,,4181,,4898,,5616,,6487/     PTDE0108
       DATAAI/,7358,,08892,,1865,,295,,4181,,5616,,7358,,08373,,1743,,273PTDE0109
      11,,3822,,5044,,6439,,07931,,1649,,2502,,3545,,461,,5814,-1.32E-5,,PTDE0110
      20373,,07436,,111,-2.97E-5,,0337,,06734,,1007,-5.14E-5,,03051,,0612PTDE0111
```

Fig. B-8 PTDENS Program Listing (Cont'd)

```
112.        32,.09175,-,0001453,,0001042,,0003599,-,000124,8,541E-5,,0003076,-9PTDE0112
113.        4,95E-5,6,714E-5,,0002542,0,/                                      PTDE0113
114.         P=PRES                                                            PTDE0114
115.         IF(P,LT,1,0) P=1,0                                                PTDE0115
116.         T=TEMP                                                            PTDE0116
117.         IF (T,LT,180,0) GO TO 45                                          PTDE0117
118.         IF (T,GE,1300,0) GO TO 25                                         PTDE0118
119.         IF (T,GE,480,0) GO TO 15                                          PTDE0119
120.         IF (P,GE,800,) GO TO 10                                           PTDE0120
121.         N=1                                                               PTDE0121
122.         GO TO 155                                                         PTDE0122
123.      10 N=2                                                               PTDE0123
124.         GO TO 155                                                         PTDE0124
125.      15 IF (P,GE,300,0) GO TO 20                                          PTDE0125
126.         N=3                                                               PTDE0126
127.         GO TO 155                                                         PTDE0127
128.      20 N=4                                                               PTDE0128
129.         GO TO 155                                                         PTDE0129
130.      25 IF (T,GE,2500,0) GO TO 35                                         PTDE0130
131.         IF (P,GE,100,0) GO TO 30                                          PTDE0131
132.         N=5                                                               PTDE0132
133.         GO TO 155                                                         PTDE0133
134.      30 N=6                                                               PTDE0134
135.         GO TO 155                                                         PTDE0135
136.      35 IF(T,GE,6000,0) T=5999,99999                                      PTDE0136
137.         IF (P,GE,10,0) GO TO 40                                           PTDE0137
138.         N=7                                                               PTDE0138
139.         N1=30                                                             PTDE0139
140.         GO TO 155                                                         PTDE0140
141.      40 N=8                                                               PTDE0141
142.         N1=29                                                             PTDE0142
143.         GO TO 155                                                         PTDE0143
144.      45 TZ=24,84+0,00317*P                                                PTDE0144
145.         IF(T,LT,TZ) T=TZ                                                  PTDE0145
146.         IF (P,LT,881,76) GO TO 60                                         PTDE0146
147.         IF (P,LT,2645,28) GO TO 50                                        PTDE0147
148.         N=9                                                               PTDE0148
149.         GO TO 155                                                         PTDE0149
150.      50 IF (P,LT,1469,6) GO TO 55                                         PTDE0150
151.         N=10                                                              PTDE0151
152.         GO TO 155                                                         PTDE0152
153.      55 N=11                                                              PTDE0153
154.         GO TO 155                                                         PTDE0154
155.      60 IF (T,GE,59,4) GO TO 75                                           PTDE0155
156.         N=12                                                              PTDE0156
157.         IF (P,GE,187,6385) GO TO 155                                      PTDE0157
158.         DO 65 I=2,20                                                      PTDE0158
159.         IF (P-PS(I)) 70,70,65                                             PTDE0159
160.      65 CONTINUE                                                          PTDE0160
161.         I=20                                                              PTDE0161
162.      70 TM=TS(I-1)+(TS(I)-TS(I-1))*(P-PS(I-1))/(PS(I)-PS(I-1))            PTDE0162
163.         IF (T,GE,TM) GO TO 125                                            PTDE0163
164.         GO TO 155                                                         PTDE0164
165.      75 IF (T,LT,108,0) GO TO 85                                          PTDE0165
166.         IF (P,LT,132,264) GO TO 80                                        PTDE0166
167.         N=13                                                              PTDE0167
168.         GO TO 155                                                         PTDE0168
169.      80 N=14                                                              PTDE0169
```

Fig. B-8 PTDENS Program Listing (Cont'd)

```
170.          GO TO 155                                                  PTDE0170
171.       85 IF (P.LT.587.84) GO TO 90                                  PTDE0171
172.          N=15                                                       PTDE0172
173.          GO TO 155                                                  PTDE0173
174.       90 IF (T.LT.72.0) GO TO 120                                   PTDE0174
175.          IF (T.LT.86.4) GO TO 105                                   PTDE0175
176.          IF (P.LT.293.92) GO TO 95                                  PTDE0176
177.          N=16                                                       PTDE0177
178.          GO TO 155                                                  PTDE0178
179.       95 IF (P.LT.73.48) GO TO 100                                  PTDE0179
180.          N=17                                                       PTDE0180
181.          GO TO 155                                                  PTDE0181
182.      100 N=18                                                       PTDE0182
183.          GO TO 155                                                  PTDE0183
184.      105 IF (P.LT.293.92) GO TO 110                                 PTDE0184
185.          N=19                                                       PTDE0185
186.          GO TO 155                                                  PTDE0186
187.      110 IF (P.LT.36.74) GO TO 115                                  PTDE0187
188.          N=20                                                       PTDE0188
189.          GO TO 155                                                  PTDE0189
190.      115 N=21                                                       PTDE0190
191.          GO TO 155                                                  PTDE0191
192.      120 IF (P.LT.293.92) GO TO 125                                 PTDE0192
193.          N=22                                                       PTDE0193
194.          GO TO 155                                                  PTDE0194
195.      125 IF (P.LT.180.0) GO TO 130                                  PTDE0195
196.          N=23                                                       PTDE0196
197.          GO TO 155                                                  PTDE0197
198.      130 IF (P.GE.29.0) GO TO 140                                   PTDE0198
199.          IF (P.LT.2.9392) GO TO 135                                 PTDE0199
200.          N=24                                                       PTDE0200
201.          GO TO 155                                                  PTDE0201
202.      135 N=25                                                       PTDE0202
203.          GO TO 155                                                  PTDE0203
204.      140 IF (T.GE.64.8) GO TO 150                                   PTDE0204
205.          IF (P.GE.102.0) GO TO 145                                  PTDE0205
206.          N=26                                                       PTDE0206
207.          GO TO 155                                                  PTDE0207
208.      145 N=27                                                       PTDE0208
209.          GO TO 155                                                  PTDE0209
210.      150 N=28                                                       PTDE0210
211.      155 IF(T.LE.5000.)N1=N                                         PTDE0211
212.          FP=(P-BP(N))/DP(N)                                         PTDE0212
213.          IP=FP                                                      PTDE0213
214.          IF(IP.GT.MX(N)) IP=MX(N)                                   PTDE0214
215.          FI=IP                                                      PTDE0215
216.          F=FP-FI                                                    PTDE0216
217.          FP=1.0-F                                                   PTDE0217
218.          FT=(T-BT(N1))/DT(N)                                        PTDE0218
219.          IT=FT                                                      PTDE0219
220.          FI=IT                                                      PTDE0220
221.          FF=FT-FI                                                   PTDE0221
222.          FT=1.0-FF                                                  PTDE0222
223.          I=IT*JP(N)+IP+LOC(N1)                                      PTDE0223
224.          J=I+JP(N)                                                  PTDE0224
225.          PTDENS=FP*FT*R(I)+F*FT*R(I+1)+FP*FF*R(J)+F*FF*R(J+1)       PTDE0225
226.          RETURN                                                     PTDE0226
227.          END                                                        PTDE0227
```

Fig. B-8 PTDENS Program Listing (Cont'd)

```
      SUBROUTINE WTCTRL(P,I,IM,II,D,S1,S2,S3,IV,IF,WT,WI)                WTCT0001
      REAL MINTHK                                                        WTCT0002
      DIMENSION RHOL(10),RHOI(10),MINTHK(20)                             WTCT0003
      DIMENSION FTU(5,2)                                                 WTCT0004
      DATA (FTU(J,1),J=1,5)/255000.,75000.,52600.,210000.,240000./       WTCT0005
      DATA (FTU(J,2),J=1,5)/305000.,94000.,63840.,219600.,288320./       WTCT0006
      DATA(RHOL(J),J=1,5)/501.12,176.26,169.34,511.49,276.48/            WTCT0007
      DATA(RHOI(J),J=1,6)/2.34,2.45,0.59,0.69,2.20,1.0/                  WTCT0008
      DATA(MINTHK(J),J=1,15)/.02,.025,.028,.02,.016,.035,.058,           WTCT0009
     1                       .065,.042,.02,.049,.083,.095,.049,.035/     WTCT0010
      WI=0.                                                              WTCT0011
      WT=0.                                                              WTCT0012
      GO TO (10,15,15,15,15,15,15,15,25,15,25,25,35,35,45,50,55,65,70,70WTCT0013
     *,70,75,80),I                                                       WTCT0014
C     SUMP                                                               WTCT0015
   10 WT=0.                                                              WTCT0016
      RETURN                                                             WTCT0017
C     EQUIVALENT LINE SECTIONS OR VENTURI                                WTCT0018
   15 IF (IM.LE.5) GO TO 20                                              WTCT0019
      IF (IM.EQ.6) GO TO 85                                              WTCT0020
      IF (IM.EQ.7) GO TO 90                                              WTCT0021
   20 CONTINUE                                                           WTCT0022
      ST=FTU(IM,IF)                                                      WTCT0023
      THKL=P*D*2.5/(2.*ST)                                               WTCT0024
      J=0                                                                WTCT0025
      IF(P.GE.1000.) J=5                                                 WTCT0026
      IF(P.GE.3000.) J=10                                                WTCT0027
      IF(THKL.LE.MINTHK(IM+J)) THKL=MINTHK(IM+J)                         WTCT0028
      WGTFT=3.1416*D*THKL*RHOL(IM)/144.                                  WTCT0029
      WT=S1*WGTFT                                                        WTCT0030
C     COMPUTE INSULATION WEIGHT                                          WTCT0031
      WI=3.1415927*S1*RHOI(II)*(D+S3/2.)/144.                            WTCT0032
      RETURN                                                             WTCT0033
   25 WRITE (6,30)I                                                      WTCT0034
   30 FORMAT('2','S/R WTCTRL - OPTION ',I3,' NOT IMPLEMENTED'/)          WTCT0035
      WT=0.                                                              WTCT0036
      RETURN                                                             WTCT0037
   35 IDV=IV+1                                                           WTCT0038
   40 WT=CFTW(D,P,IDV)                                                   WTCT0039
      RETURN                                                             WTCT0040
   45 IDV=4                                                              WTCT0041
      GO TO 40                                                           WTCT0042
   50 IDV=1                                                              WTCT0043
      GO TO 40                                                           WTCT0044
C     U-PIN TIE ROD BELLOWS                                              WTCT0045
   55 IB=1                                                               WTCT0046
   60 WT=CBWT(D,P,IB)                                                    WTCT0047
      RETURN                                                             WTCT0048
C     PIN OR HINGE JOINT BELLOWS                                         WTCT0049
   65 IB=2                                                               WTCT0050
      GO TO 60                                                           WTCT0051
C     EXTERNAL OR INTERNAL GIMBAL BELLOWS                                WTCT0052
   70 IB=3                                                               WTCT0053
```

Fig. B-9 WTCTRL Program Listing

```
54,          GO TO 60                                                    WTCT0054
55,    C     PRESSURE-VOLUME COMPENSATOR                                 WTCT0055
56,       75 IB=4                                                        WTCT0056
57,          GO TO 60                                                    WTCT0057
58,    C     INTERNAL BALL-STRUT BELLOWS                                 WTCT0058
59,       80 IB=5                                                        WTCT0059
60,          GO TO 60                                                    WTCT0060
61,    C     COMPUTE WEIGHT OF VACUUM-JACKETED CRES LINE (321/347)       WTCT0061
62,       85 A=0,217684                                                  WTCT0062
63,          B=-6,69016E-03                                              WTCT0063
64,          GO TO 95                                                    WTCT0064
65,    C     COMPUTE WEIGHT OF VACUUM-JACKETED ALUMINUM (2219)           WTCT0065
66,       90 A=0,359277                                                  WTCT0066
67,          B=-2,00888E-02                                              WTCT0067
68,       95 WT=S1/(A+B*D)                                               WTCT0068
69,          RETURN                                                      WTCT0069
70,          END                                                         WTCT0070
```

Fig. B-9 WTCTRL Program Listing (Cont'd)

```
      FUNCTION CFTW (D,P,IDV)                                          CFTW0001
C                                                                      CFTW0002
      REAL K1,K2,K3,K4                                                 CFTW0003
C                                                                      CFTW0004
      DIMENSION K1(4),K2(4),K3(4),K4(4),C1(4),C2(4),C3(4),C4(4)        CFTW0005
C                                                                      CFTW0006
      DATA K1/0.040,0.057,0.073,0.090/                                 CFTW0007
      DATA K2/0.057,0.073,0.090,0.107/                                 CFTW0008
      DATA K3/1.000,2.500,3.300,5.500/                                 CFTW0009
      DATA K4/2.500,3.300,5.500,7.700/                                 CFTW0010
      DATA C1/1.750,3.950,5.730,8.910/                                 CFTW0011
      DATA C2/3.950,5.730,8.910,12.35/                                 CFTW0012
      DATA C3/0.800,1.500,2.500,3.500/                                 CFTW0013
      DATA C4/1.500,2.500,3.500,4.500/                                 CFTW0014
C                                                                      CFTW0015
C                    SET IDV TO EXTRA HEAVY IF NOT INPUT               CFTW0016
      IF (IDV .EQ. 0) IDV = 4                                          CFTW0017
      IF (D.LE.1.) GO TO 15                                            CFTW0018
      IF (P.GT.300.0.AND.D.GT.3.5) GO TO 10                            CFTW0019
      IF (P.GT.1000.0.AND.D.LE.3.5) GO TO 10                           CFTW0020
      CFTW = K1(IDV)*D*D*D + C1(IDV)                                   CFTW0021
      RETURN                                                           CFTW0022
   10 CFTW = K2(IDV)*D*D*D + C2(IDV)                                   CFTW0023
      RETURN                                                           CFTW0024
   15 IF (P.GE.1000.) GO TO 20                                         CFTW0025
      CFTW = K3(IDV)*D + C3(IDV)                                       CFTW0026
      RETURN                                                           CFTW0027
   20 CFTW = K4(IDV)*D + C4(IDV)                                       CFTW0028
      RETURN                                                           CFTW0029
      END                                                              CFTW0030
```

Fig. B-10 CFTW Program Listing

```
 1.          FUNCTION CBWT(D,P,IB)                                          CBWT0001
 2.          REAL M                                                         CBWT0002
 3.          DIMENSION C1(5),C2(5),M(5)                                     CBWT0003
 4.          DATA C1/.07384,.1255,.1006,14.26,.09489/                       CBWT0004
 5.          DATA C2/.10301,.1731,.1262,18.495,.12892/                      CBWT0005
 6.          DATA M/2.05,2.305,2.55,1.111,2.354/                            CBWT0006
 7.          CBWT=C1(IB)*D**M(IB)                                           CBWT0007
 8.          IF(P.LE.150.) RETURN                                           CBWT0008
 9.          IF (P.LT.300.) GO TO 10                                        CBWT0009
10.          CBWT=CBWT*C2(IB)/C1(IB)                                        CBWT0010
11.          RETURN                                                         CBWT0011
12.       10 CBWT=CBWT+(P-150.)*CBWT*(C2(IB)/C1(IB)-1.)/150.                CBWT0012
13.          RETURN                                                         CBWT0013
14.          END                                                            CBWT0014
```

Fig. B-11 CBWT Program Listing

```
    C                                                                   GOMT0001
          FUNCTION CONE (R,H)                                           GOMT0002
    C                                                                   GOMT0003
          INCLUDE  UCONST,LIST                                          GOMT0004
    C                                                                   GOMT0005
    C                     VOLUME OF CONE (CIRCULAR)                     GOMT0006
          CONE = PI*R*R*H / 3.0                                         GOMT0007
          RETURN                                                        GOMT0008
    C                     VOLUME OF CYLINDER (RIGHT-CIRCULAR)           GOMT0009
          ENTRY CYLNDR (R,H)                                            GOMT0010
          CONE = PI*R*R*H                                               GOMT0011
          RETURN                                                        GOMT0012
    C                     VOLUME BETWEEN CYLINDER AND SPHEROID          GOMT0013
    C                     RROT IS ALONG AXIS OF ROTATION                GOMT0014
          ENTRY CYLSPH (RROT,R)                                         GOMT0015
          CONE = PI*R*R*RROT / 3.0                                      GOMT0016
          RETURN                                                        GOMT0017
    C                     VOLUME OF FRUSTRUM OF CONE (CIRCULAR)         GOMT0018
          ENTRY FRCONE (R,H,R2)                                         GOMT0019
          CONE = PI*H*(R*R + R2*R2 + R*R2) / 3.0                        GOMT0020
          RETURN                                                        GOMT0021
    C                     VOLUME OF HEMISPHERE OR HALF OF SPHEROID      GOMT0022
    C                     RROT IS ON AXIS OF ROTATION                   GOMT0023
          ENTRY HSPHER (RROT,R)                                         GOMT0024
          CONE = PI2D3*R*R*RROT                                         GOMT0025
          RETURN                                                        GOMT0026
    C                     VOLUME OF SPHERE OR SPHEROID                  GOMT0027
    C                     RROT IS ALONG AXIS OF ROTATION                GOMT0028
          ENTRY SPHERE (RROT,R)                                         GOMT0029
          CONE = 2.0*PI2D3*R*R*RROT                                     GOMT0030
          RETURN                                                        GOMT0031
    C                                                                   GOMT0032
    C                     AREA OF CYLINDER                              GOMT0033
          ENTRY ARACYL (R,H)                                            GOMT0034
          CONE = 2.0*PI*R*H                                             GOMT0035
          RETURN                                                        GOMT0036
    C                                                                   GOMT0037
    C                     AREA OF FRUSTRUM                              GOMT0038
          ENTRY AREAFR (R,H,R2)                                         GOMT0039
          CONE = PI*(R+R2)*SQRT (H*H+(R-R2)**2)                         GOMT0040
          RETURN                                                        GOMT0041
    C                                                                   GOMT0042
    C                     AREA OF HALF OF SPHEROID                      GOMT0043
    C                     RROT ALONG AXIS OF ROTATION                   GOMT0044
          ENTRY ARSPHR (RROT,R)                                         GOMT0045
          IF (RROT.LE.R) GO TO 10                                       GOMT0046
    C                     ROTARED ABOUT MAJOR AXIS                      GOMT0047
    C                     E = ECCENTRICITY FOR ELLIPSE                  GOMT0048
          E = SQRT (RROT*RROT - R*R)/RROT                               GOMT0049
          CONE = PI*R*(R+RROT*ASIN(E)/E)                                GOMT0050
          RETURN                                                        GOMT0051
       10 IF (RROT.EQ.R) GO TO 15                                       GOMT0052
    C                     ROTARED ABOUT MINOR AXIS                      GOMT0053
```

Fig. B-12 GOMTRY Program Listing

```
54,          E = SQRT (R*R - RROT*RROT) / R                                    GOMT0054
55,          CONE = PI*(R*R+(RROT*RROT/(2,*E))*ALOG((1,+E)/(1,-E)))            GOMT0055
56,          RETURN                                                            GOMT0056
57,    C                     AREA OF HEMISPHERE                               GOMT0057
58,       15 CONE = 2,*PI*R*R                                                  GOMT0058
59,          RETURN                                                            GOMT0059
60,          END                                                               GOMT0060
```

Fig. B-12 GOMTRY Program Listing (Cont'd)

```
      C                                                                 SPHS0001
      SUBROUTINE SPHSEG (PVOL,RAD,H)                                    SPHS0002
      C                                                                 SPHS0003
      INCLUDE  UCONST,LIST                                              SPHS0004
      C                                                                 SPHS0005
      DIMENSION Y(3)                                                    SPHS0006
      C                                                                 SPHS0007
      C                     CALC. VOL. OF TOTAL HEMISPHERE              SPHS0008
      TVOL = PI2O3 * RAD**3                                             SPHS0009
      GO TO 10                                                          SPHS0010
      C                     ENTRY FOR ELLIPTICAL SPHEROID               SPHS0011
      C                     RAD ALONG AXIS OF ROTATION                  SPHS0012
      ENTRY ELIPSG (PVOL,RAD,RPD,H)                                     SPHS0013
      C                                                                 SPHS0014
      TVOL = PI2O3*RPD*RPD*RAD                                          SPHS0015
   10 CONTINUE                                                          SPHS0016
      XM = PVOL / TVOL                                                  SPHS0017
      IF (XM.GT.0.) GO TO 15                                            SPHS0018
      WRITE (6,40)XM                                                    SPHS0019
      RETURN                                                            SPHS0020
   15 CONTINUE                                                          SPHS0021
      PHI3 = ACOS (1.0-XM) / 3.0                                        SPHS0022
      DO 20 I=1,3                                                       SPHS0023
      XI = I - 1                                                        SPHS0024
      Y(I) = RAD*(1.0 + 2.0*COS (PHI3 + XI*PI2O3))                      SPHS0025
   20 CONTINUE                                                          SPHS0026
      DO 25 I=1,3                                                       SPHS0027
      K = I                                                             SPHS0028
      IF (Y(I).GT.0..AND.Y(I).LT.RAD) GO TO 30                          SPHS0029
   25 CONTINUE                                                          SPHS0030
      WRITE (6,35)Y                                                     SPHS0031
      RETURN                                                            SPHS0032
   30 H = Y(K)                                                          SPHS0033
      RETURN                                                            SPHS0034
      C                                                                 SPHS0035
      C                     RAD ALONG AXIS OF ROTATION                  SPHS0036
      ENTRY CYMSPH (PVOL,RAD,RPD,H)                                     SPHS0037
      C                                                                 SPHS0038
      C                     TO CALC. HEAD IN A VOLUME BETWEEN A CYLINDER AND  SPHS0039
      C                     SPHEROID                                    SPHS0040
      D = 3.0*RAD*RAD*PVOL / (PI*RPD*RPD)                               SPHS0041
      H = RAD - (RAD**3 - D)**(1./3.)                                   SPHS0042
      RETURN                                                            SPHS0043
      C                                                                 SPHS0044
   35 FORMAT ('0' 10X 'COULD NOT FIND H FOR HEMISPHERE' 3F15.4/)        SPHS0045
   40 FORMAT ('0' 10X 'ERROR INPUT TO SPHSEG' F15.7)                    SPHS0046
      C                                                                 SPHS0047
      END                                                               SPHS0048
```

Fig. B-13 SPHSEG Program Listing

APPENDIX C

SOPSA PROGRAM AND SUBROUTINE DICTIONARY

This appendix contains an alphabetic listing of all the alphanumeric names (variables, subroutines, functions, etc.) used in the SOPSA program. Following each entry in the list is a set of line numbers. These are the lines on which the entry appears in the program listing (Appendix A). Similar tables are presented for statement numbers and transfer statements used in the program.

Following each entry and each line number is a set of flags. These flags indicate the type of entry and how the entry is used each time it appears. The heading of each table explains the meaning of these flags. The name of the COMMON block is also listed in the error flag field for any variable name appearing in a named COMMON block.

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Table C-1

STAR DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

V A R I A B L E T A B L E

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

AAA	LBCM	CM CM CM CM		76E	77E	78E	79E										
ABC	DMVR	DM EQ EQ EQ **		64E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E
				65E	65E	65E	65E	65E	65E	65E	98C						
ADH	DMVR	DM		65E	422A	809B											
ADO	DMVR	DM		65E	394A	757B											
ADOME		CM	DIMEN	17E	9250												
AMAX1	FCTN			746B	798B												
ASKIN		CM	DIMEN	17E	9250												
ATOT		CM	DIMEN	17E	9250												
A1		CM	DIMEN	17E													
A2		CM	DIMEN	17E													
A3		CM	DIMEN	17E													
A4		CM	DIMEN	17E													
A6		CM	DIMEN	17E													
A7		CM	DIMEN	17E													
BBB	LBCM	CM		80E													
CCC	LBCM	CM		81E													
CONGP				531A	547B	563B	570A	586B	602B								
D				530A	541C	544B	557C	560B	569A	580C	583B	596C	599B				
DDD	LBCM	CM		82E													
DELTIM				490A	491B	493B	494B	495B									
DFWGTW	DMVR	DM		27E	488A	489B	494B	509B	586B	602B							
DFWGTO	DMVR	DM		27E	487A	489B	493B	506B	547B	563B							
DIA				750A	761C	773A	783C	802A	813C	825A	835C						
DIFWGT	DMVR	DM CM	FFF	26E	86E	489A	491B	495B									
DIMEN	LBCM	CM		17E													
DLPACW	DMVR	DM EQ		43E	65E	455A	463A	631B	639B	715B	733B	10850	1157A	11600			
DLPACO	DMVR	DM EQ		43E	65E	436A	444A	630B	636B	712B	732B	10690	1141A	11440			
DLPHDW	DMVR	DM CM	FFF	26E	86E	521A	639B	10380									
DLPHDO	DMVR	DM CM	FFF	26E	86E	520A	636B	10380									
DLPLNW	DMVR	DM EQ		44E	65E	586A	602A	631B	639B	715B	733B	11180	1158A	11600			
DLPLNO	DMVR	DM EQ		44E	65E	547A	563A	630B	636B	712B	732B	11030	1142A	11440			
E				729B	730B												
EEE	LBCM	CM		84E													
EQLR	DMVR	CM	DIMEN	17E	471A												
EQLR1	DMVR	DM		2ME	1551	471B	948O										
EXIT	SBRT			1359B													
FEET		DA		93A	471B												
FFF	LBCM	CM CM CM		66E	88E	89E											
FIFRAC	DMVR	DM CM	AAA	29E	76E	2991	500B	10140									
FINDR	FCTN			688B													
FLORES	SBRT			541B	557B	580B	596B										
FNOM	DMVR	DM CM	DDD	32E	82E	2601	500B	9180									
FTOW	DMVR	DM CM	FFF	26E	86E	500A	501B	502A	520B	521B	673B	675B	702B	704B	10380		
GC	DMVR	DM CM DA	CCC	32E	81E	93A	436B	444B	455B	463B							

STAR DICTIONARY (CONT'D)

GGG	LBCM	CM	CM		90E	91E											
HCAYP		CM		EEE	84E	568A	581A	581B	583A	583B	584B	586B	597A	597B	599A	599B	603B	602B
HDDUM		CM		EEE	84E	449A	455B	463B										
HDH2		CM		DIMEN	17E	478B	516B	521B										
HDLDUM		CM		EEE	84E	567A	586B	602B										
HDO2		CM		DIMEN	17E	477B	515B	520B										
HDTINC		CM		EEE	84E													
HEADH2	DMVR	DM	CM	GGG	30E	90E	516A	675B	12240									
HEADIH		CM		FFF	89E	478A	9250											
HEADIO		CM		FFF	89E	477A	9250											
HEADO2	DMVR	DM	CM	GGG	30E	90E	515A	673B	12240									
HKPD	DMVR	DM	CM	DDD	31E	82E	584A	600A	9610	9630								
HPD	DMVR	DM	CM	DDD	31E	82E	2251	408B	416B	449B	567B	569B	802B	825B	9610	9630	10830	11130
					11870	12540	12850	13160	13450									
HPDUM		CM		EEE	84E	448A	455B	461A	463B									
HPIPEL	DMVR	DM	CM	DDD	31E	82E	410A	422B	448B	583B	9610							
HYHTLN	DMVR	DM	CM	DDD	39E	82E	2401	521B	704B	9250								
H2-----	DMVR	DM	DA		61E	94A	13450	13450										
I					109D	109L	177J	178D	178D	178D	178D	178D	178D	180D	181D	182D	182D	183D
					188J	189D	189D	189D	189D	189D	189D	191D	192D	193D	193D	194D	206J	207D
					207D	207D	207D	207D	207D	209D	210D	211D	211D	212D	216J	217D	217D	217D
					217D	217D	217D	219D	220D	221D	221D	222D	281D	281L	289D	289L	291D	291L
					299D	299L	376J	377D	378D	384D	385D	404J	405D	406D	412D	413D	427J	429D
					430D	431B	436D	444D	448D	449D	450B	455D	463D	470J	471D	471D	526J	528D
					530D	532B	536D	538D	539D	540D	544D	545D	547D	561D	563D	567D	569D	571B
					575D	577D	578D	579D	583D	584D	586D	600D	602D	623J	636D	636D	635D	639D
					639D	639D	653J	657D	657D	657D	658D	658D	661D	661D	661D	662D	662D	668J
					669D	670D	673D	673D	675D	675D	675D	676D	676D	676D	677D	677D	677D	677D
					686A	687D	689D	693D	709J	712D	712D	712D	712D	715D	715D	715D	715D	722J
					725D	724D	737D	737D	738D	738D	739D	739D	739D	739D	740D	740D	740D	740D
					746D	746D	746D	747D	750D	757D	760D	766D	787D	788D	792D	793D	794D	794D
					794D	795D	795D	795D	796D	796D	795D	798D	798D	798D	799D	802D	809D	817D
					818D	839D	840D	844D	845D	846D	846D	846D	847D	847D	847D	848D	848D	848D
					901D	901L	973J	974D	974D	974D	974D	974D	974D	974D	983J	984D	984D	984D
					984D	984D	984D	984D	991J	992D	992D	992D	992D	992D	992D	992D	1003J	1001D
					1001D	1001D	1001D	1001D	1001D	1001D	1001D	1024D	1024L	1051D	1051L	1069D	1069L	1077D	1077L
					1085D	1085L	1094D	1094L	1103D	1103L	1111D	1111L	1118D	1118L	1127D	1127L	1140J	1141D
					1142D	1144D	1144L	1144D	1144L	1149D	1149L	1156J	1157D	1158D	1160D	1160L	1160D	1160L
					1168D	1168L	1177D	1177L	1185D	1185L	1192D	1192L	1201D	1201L	1223A	1224D	1224D	1224D
					1224D	1246D	1246L	1259D	1259L									
ICASE					99A	111A	111B	13500										
ID					377A	378A	379B	382B	383B	405A	406A	407B	410B	411B	538A	541C	554A	557C
					577A	580C	593A	596C	753A	757B	760B	760B	761C	775A	782B	782B	783C	805A
					809B	812B	812B	813C	827A	834B	834B	835C						
IDELH	DMVR	DM			57E	2171	219B	220B	221B	222A	405B	577B	827B	10010				
IDELO	DMVR	DM			54E	1891	191B	192B	193B	194A	377B	538B	775B	9840				
IDH	DMVR	DM			58E	211A	812B											
IDHE	DMVR	DM			58E	221A	834B											
IDMLH	DMVR	DM			56E	2071	209B	210B	211B	212A	406B	593B	805B	9920				
IDMLO	DMVR	DM			53E	1781	180B	181B	182B	183A	378B	554B	753B	9740				
IDO	DMVR	DM			58E	182A	760B											
IDOE	DMVR	DM			58E	193A	782B											
IDV					752A	760A	761C	778A	782A	783C	804A	812A	813C	830A	834A	835C		
IGOON		CM		BBB	80E	3511	1353B											
II					755A	761C	777A	783C	807A	813C	829A	835C						
IIELH	DMVR	DM			57E	2171	829B	10010										
IIELO	DMVR	DM			54E	1891	777B	9840										

STAR DICTIONARY (CONT'D)

| | | |

					1160D	1174J	1175D	1176B	1177D	1189J	1190D	1191B	1192D	1219J	1220D
					1222B	1224D	1224D	1224D	1224D	1224D	1224D	1224D	1224D	1224D	1224D
					1224D	1224D	1224D	1224D	1224D	1224D	1224D	1224D	1224D	1237D	1237L
					1245J	1246D	1252D	1252L	1256J	1257D	1258B	1259D	1268D	1268L	1274J
					1275D	1276B	1277D	1283D	1283L	1287J	1288D	1289B	1290D	1299D	1299L
					1305J	1306D	1307B	1308D	1314D	1314L	1318J	1319D	1320B	1321D	
NEL					142I	146B	147B	176I	186J	205I	214J	374B	375B	377B	378B
					384B	385B	402B	403B	405B	406B	412B	413B	431B	450B	532B
					571B	629J	731J	769J	821J	960B	977J	994J	1139B	1155B	
NELP					147A	393J	421J	623J	653J	668J	686B	709J	722J	1047B	10550
					10690	10800	10850	10980	11030	11130	11180	11400	11560	11720	11770
					11870	11920	12230	12410	12460	12540	12590	12720	12770	12850	12900
					13030	13080	13160	13210	1339J	1344J					
NGST					142I	502B									
NID					537J	538D	539D	540D	553J	554D	555D	556D	576J	577D	578D
					579D	592J	593D	594D	595D						
NL					176D	176L	186J	187D	189D	189D	189D	189D	189D	189D	189D
					191D	192D	193D	193D	194D	205D	205L	214J	215D	217D	217D
					217D	217D	217D	219D	220D	221D	222D	372J	374B	374D	375B
					377B	377D	378B	380D	384B	384D	385B	388D	390D	393J	394D
					394D	400J	402B	402D	403B	405B	405D	406B	408D	412B	412D
					413B	416D	418D	421J	422D	422D	769J	772D	773D	775D	776D
					777D	779D	780D	781D	782D	787D	788D	821J	824D	825D	827D
					828D	829D	831D	832D	833D	834D	839D	840D	977J	978D	979D
					984D	984D	984D	984D	984D	984D	984D	994J	995D	996D	1001D
					1001D	1001D	1001D	1001D	1001D	1001D					
NMA					1047A	10550	10690	10800	10850	10980	11030	11130	11180	11720	11770
					11870	11920	12410	12460	12540	12590	12720	12770	12850	12900	13030
					13080	13160	13210								
NML					142I	146B									
NOP		CM			BBB	80E	142I	444B	463B	563B	602B	9130	11690	11860	12380
					12530	12690	12840	13000	13150						
NOP1		CM			BBB	80E	142I	491B	493B	494B	495B	500B	506B	509B	9180
NPSPH	DMVR	DM	RL	CM	AAA	33E	73E	76E	3091	620B	10140				
NPSPO	DMVR	DM	RL	CM	AAA	33E	73E	76E	3071	617B	10140				
NPTS		CM			BBB	80E	142I	281I	289I	291I	299I	307I	309I	318I	320I
					329I	331I	340I	342I	360B	1013J	1034J	1037B	1065J	1068B	1082J
					1084B	1100J	1102B	1115J	1117B	1136J	1138B	1152J	1154B	1174J	1176B
					1189J	1191B	1219J	1222B	1243J	1245B	1256J	1258B	1274J	1276B	1287J
					1289B	1305J	1307B	1318J	1320B						
NSIZE		CM			BBB	80E	146A	197I	225I	372J	393J	400J	421J	427J	526J
					623J	653J	668J	709J	722J	9050	959J	1339J	1344J		
OCAYP		CM			EEE	84E	529A	542A	542B	544A	544B	545B	547B	558A	558B
					560A	560B	561B	563B							
ODDUM		CM			EEE	84E	430A	436B	444B						
ODLDUM		CM			EEE	84E	528A	547B	563B						
ODTINC		CM			EEE	84E									
OKPD	DMVR	DM	CM		DDD	31E	82E	545A	561A	9610	9630				
OPD	DMVR	DM	CM		DDD	31E	82E	197I	380B	388B	430B	524B	530B	750B	773B
					9610	9630	10550	10980	11720	12410	12720	13030	13400		
OPDUM		CM			EEE	84E	429A	436B	442A	444B					
OPIPEL	DMVR	DM	CM		DDD	31E	82E	390A	394B	429B	544B	9610			
OXHTLN	DMVR	DM	CM		DDD	39E	82E	240I	520B	702B	9250				
O2	DMVR	DM	DA			61E	94A	13400	13400						
PCWGTH	DMVR	DM	CM		FFF	27E	86E	494A	10380						
PCWGTO	DMVR	DM	CM		FFF	27E	86E	493A	10380						
PDES						747A	761C	783C	799A	813C	835C				
PDESH	DMVR	DM				60E	798A	799B							
PDESO	DMVR	DM				60E	746A	747B							
PDLH						2401	798C	9410							
PDLO						2401	746C	9410							
PENGH	DMVR	DM	CM		FFF	35E	86E	620A	621B	621A	639B	10310			
PENGO	DMVR	DM	CM		FFF	35E	86E	617A	618B	618A	636B	10310			
PENWH	DMVR	DM	CM		DDD	34E	82E	320I	621B	621A	10140				

STAR DICTIONARY (CONT'D)

PENMNO	DMVR	DM	CM		DDD	34E	82E	3181	618B	618B	10140				
PENMUH	DMVR	DM				45E	738A	740B	740B						
PENMUO	DMVR	DM				45E	737A	739B	739B						
PENNUH	DMVR	DM	EQ			45E	65E	715A	738B	13210					
PENNUO	DMVR	DM	EQ			45E	65E	712A	737B	13080					
PENTOL		CM			DDD	82E	2731	636B	639B	9250					
PHDLNH	DMVR	DM				47E	704A	715B	12240						
PHDLNO	DMVR	DM				47E	702A	712B	12240						
PI	DMVR	DM	DA			32E	96A	436B	444B	455B	463B				
PI2O3		DA				96A									
PMAXH	DMVR	DM				60E	724A	740B	740A	798C					
PMAXO	DMVR	DM				59E	723A	739B	739A	746C					
PNCWGT		CM			EEE	84E	483A	495A	495B	496B					
PPDGHT	DMVR	DM	CM		AAA	37E	77E	3311	660B	10140					
PPDGOT	DMVR	DM	CM		AAA	37E	77E	3291	656B	10140					
PPVAPH		CM			FFF	88E									
PPVAPO		CM			FFF	88E									
PROWGT	DMVR	DM				42E	496A	10380							
PSVAPH		CM			FFF	88E	650C	651B							
PSVAPO		CM			FFF	88E	647C	648B							
PTBTMH	DMVR	DM				59E	670A	677B	677A	798C					
PTBTMO	DMVR	DM				59E	669A	676B	676A	746C					
PTDENS	FCTN					693B									
PTKBTH	DMVR	DM	EQ			47E	65E	675A	677B	677B	715B	12240	12900		
PTKBTO	DMVR	DM	EQ			47E	65E	673A	676B	676B	712B	12240	12770		
PULLH	DMVR	DM	EQ			46E	65E	639A	661B	661B	662B	11920			
PULLO	DMVR	DM	EQ			46E	65E	636A	657B	657B	658B	11770			
PULLRH	DMVR	DM	EQ			48E	65E	661A	662A	675B	693C	12240	12590		
PULLRO	DMVR	DM	EQ			48E	65E	657A	658A	673B	687C	689B	12240	12460	
PULMNH	DMVR	DM				48E	660A	661B	662B	662B					
PULMNO	DMVR	DM				48E	656A	657B	658B	658B					
PUVAPH		CM			FFF	88E	651A	660B	12240						
PUVAPO		CM			FFF	88E	648A	656B	12240						
PVAPH		CM			EEE	84E	613C	614B							
PVAPO		CM			EEE	84E	610C	611B							
PVAPOR	SBRT					610B	613B	647B	650B						
PVPENH		CM			EEE	84E	614A	620B							
PVPENO		CM			EEE	84E	611A	617B							
RES						541C	542B	557C	558B	580C	581B	596C	597B		
RHOHY	DMVR	DM	DA			32E	95A	356B	509B	521B	586B	602B	675B	704B	
RHOLHC						693A	694B								
RHOLOC						689A	690B								
RHOCX	DMVR	DM	CM	DA	CCC	32E	81E	95A	355B	506B	520B	547B	563B	673B	702B
RHOHY		CM			CCC	81E									
ROX						688A	689B								
SPEC						384A	385A	386B	412A	413A	414B				
SP1						539A	541C	555A	557C	578A	580C	594A	596C	756A	757A	757B	761C	779A	783C
						808A	809A	809B	813C	831A	835C				
SP1ELH	DMVR	DM				57E	2171	412B	578B	831B	10010				
SP1ELO	DMVR	DM				54E	1891	384B	539B	779B	9840				
SP1MLH	DMVR	DM				56E	2071	413B	594B	808B	9920				
SP1MLO	DMVR	DM				53E	1781	385B	555B	756B	9740				
SP2						540A	541C	556A	557C	579A	580C	595A	596C	758A	761C	780A	783C	810A	813C
						832A	835C								
SP2ELH	DMVR	DM				58E	2171	579B	832B	10010					
SP2ELO	DMVR	DM				55E	1891	540B	780B	9840					
SP2MLH	DMVR	DM				56E	2071	595B	810B	9920					
SP2MLO	DMVR	DM				53E	1781	556B	758B	9740					

Table C-1

STAR DICTIONARY (CONT'D)

SP3					759A	761C	781A	783C	811A	813C	833A	835C						
SP3ELH	DMVR	DM			49E	217I	833B	10010										
SP3ELO	DMVR	DM			49E	189I	781B	9840										
SP3MLH	DMVR	DM			49E	207I	811B	9920										
SP3MLO	DMVR	DM			49E	178I	759B	9740										
ST	DMVR	DM	CM	DDD	39E	82E	109I	9010	10240	10510	10770	10940	11110	11270	11490	11680	11850	12010
					12370	12520	12680	12830	12990	13140	13290							
SUM					373A	380A	380B	386A	386B	388A	389B	390B	401A	408A	408B	414A	414B	416A
					416B	418B	748A	762A	762B	765B	770A	784A	784B	787B	789B	800A	814A	814B
					817B	822A	836A	836B	839B	841B								
SUMH					626A	631A	633B	633B	733A	735B	735B							
SUMI					749A	763A	763B	766B	771A	785A	785B	788B	790B	801A	815A	815B	818B	823A
					837A	837B	840B	842B										
SUMIT					768A	790A	790B	793B	820A	842A	842B	845B						
SUMMH	DMVR	DM			59E	628A	633B	633A	639B	715B	738B							
SUMMO	DMVR	DM			59E	627A	632B	632A	636B	712B	737B							
SUMNH	DMVR	DM			60E	730A	735B	735A	738B									
SUMNO	DMVR	DM			60E	729A	734B	734A	737B									
SUMO					625A	630A	632B	632B	732A	734B	734B							
SUMT					767A	789A	789B	792B	819A	841A	841B	844B						
SYSNUM		IN	CM	BBB	72E	80E	142I	290B	308B	319B	330B	341B	368B	396B	428B	447B	527B	566B
					616B	619B	635B	638B	655B	659B	672B	674B	684B	691B	701B	703B	711B	714B
					745B	797B	907B	967B	987B	1048B	1075B	1092B	1109B	1125B	1147B	1166B	1183B	1235B
					1250B	1266B	1281B	1297B	1312B	1338B								
TDGHT	DMVR	DM	CM	AAA	35E	78E	342I	692B	10140									
TDGOT	DMVR	DM	CM	AAA	35E	78E	340I	685B	10140									
TENINH	DMVR	DM	CM	DDD	36E	82E	273I	612B	9250									
TENINO	DMVR	DM	CM	DDD	36E	82E	273I	609B	9250									
TIMEA	DMVR	DM	CM	AAA	29E	76E	281I	362B	362B	363B	363B	490B	490B	506B	506B	509B	509B	10140
					10350	10660	10830	11010	11160	11370	11530	11750	11900	12200	12440	12570	12750	12880
					13060	13190												
TLIGSH	DMVR	DM	CM	AAA	37E	77E	273I	649B	692B									
TLIGSO	DMVR	DM	CM	AAA	37E	77E	273I	646B	685B									
TMPULH					692A	693C												
TMPULO					685A	687C	689B											
TOTMLH					144I	422B	461B	599B	9630									
TOTMLO					144I	394B	442B	560B	9630									
TSVAPH			CM	AAA	77E	649A	650C											
TSVAPO			CM	AAA	77E	646A	647C											
TVAPH			CM	EEE	84E	612A	613C											
TVAPO			CM	EEE	84E	609A	610C											
ULLHED	SBRT				474B	512B												
ULVH2			CM	GGG	90E													
ULVLH2	DMVR	DM	CM	GGG	38E	91E	514A	694B	12240									
ULVLIH			CM	FFF	89E	476A	9250											
ULVLIO			CM	FFF	89E	475A	9250											
ULVLO2	DMVR	DM	CM	GGG	38E	91E	513A	690B	12240									
ULVO2			CM	GGG	90E													
UVLH2			CM	DIMEN	17E	476B	514B											
UVLO2			CM	DIMEN	17E	475B	513B											
VLH2					485A	509A	509B	510B	511B									
VLO2					484A	506A	506B	507B	508B									
VLQH2	DMVR	DM			38E	510A												
VLQO2	DMVR	DM			38E	507A												
VRMH2					511A	512C												
VRMO2					508A	512C												
VTH2			CM	DIMEN	17E													
VTOI			CM	DIMEN	17E													

Table C-1

STAR DICTIONARY (CONT'D)

VTO2		CM		DIMEN	17E							
VWGTCH		CM		EEE	84E	482A	491A	491B	492B			
VWGTN	DMVR	DM	CM	CCC	32E	81E	250I	482B	9180			
VWGTNU	DMVR	DM	CM	FFF	26E	86E	492A	500B	10380			
V1		CM		DIMEN	17E							
V2		CM		DIMEN	17E							
V3		CM		DIMEN	17E							
V4		CM		DIMEN	17E							
V5		CM		DIMEN	17E							
V6		CM		DIMEN	17E							
V7		CM		DIMEN	17E							
WDDOTH	DMVR	DM	CM	FFF	40E	86E	363A	455B	463B	10380		
WDDOTO	DMVR	DM	CM	FFF	40E	86E	362A	436B	444B	10380		
WDOTNH	DMVR	DM	CM	DDD	39E	82E	260I	363B	488B	9180		
WDOTNO	DMVR	DM	CM	DDD	39E	82E	260I	362B	487B	9180		
WDTFRH	DMVR	DM	CM	AAA	29E	76E	291I	363B	363B	488B	488B	10140
WDTFRO	DMVR	DM	CM	AAA	29E	76E	289I	362B	362B	487B	487B	10140
WELH	DMVR	DM	EQ		61E	65E	839A	13450				
WELHT	DMVR	DM	EQ		61E	65E	844A	846B	13450			
WELIH	DMVR	DM			51E	840A						
WELIHT	DMVR	DM			51E	845A	847B	13450				
WELIO	DMVR	DM			50E	788A						
WELIOT	DMVR	DM			50E	793A	795B	13400				
WELO	DMVR	DM	EQ		62E	65E	787A	13400				
WELOT	DMVR	DM	EQ		62E	65E	792A	794B	13400			
WGT					761C	762B	783C	784B	813C	814B	835C	836B
WI					761C	763B	783C	785B	813C	815B	835C	837B
WLHT	DMVR	DM	EQ		61E	65E	846A	848B				
WLHTT	DMVR	DM			51E	848A	13450					
WLIHT	DMVR	DM			51E	847A	848B					
WLIOT	DMVR	DM			50E	795A	796B					
WLOT	DMVR	DM	EQ		62E	65E	794A	796B				
WLOTT	DMVR	DM			50E	796A	13400					
WMLH	DMVR	DM	EQ		61E	65E	817A	846B	13450			
WMLIH	DMVR	DM			51E	818A	847B	13450				
WMLIO	DMVR	DM			50E	766A	795B	13400				
WMLO	DMVR	DM	EQ		62E	65E	765A	794B	13400			
WTCTRL	SBRT				761B	783B	813B	835B				
WTULGH	DMVR	DM	CM	GGG	41E	90E	694A	12240				
WTULGO	DMVR	DM	CM	GGG	41E	90E	690A	12240				
Z					687C	689B						
ZFIND	SBRT				687B							
ZLPACH	DMVR	DM	CM	FFF	42E	86E						
ZLPACO	DMVR	DM	CM	FFF	42E	86E						
ZLPLNH	DMVR	DM	CM	FFF	42E	86E						
ZLPLNO	DMVR	DM	CM	FFF	42E	86E						

STAR DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	109	109D	1353X														
15	110	109S	1100														
20	115	113V	115D														
25	122	121S	122D														
30	143	142S	143D	176S	205S	351S											
35	150	123X	150D														
40	157	150X	157D														
45	184	178S	184D	189S	207S	217S											
50	185	177V	180X	185D													
55	195	188V	191X	195D													
60	196	186V	196D														
65	200	157X	200D														
70	213	206V	209X	213D													
75	223	216V	219X	223D													
80	224	214V	224D														
85	227	200X	227D														
90	243	227X	243D														
95	253	243X	253D														
100	261	144S	155S	197S	225S	240S	250S	260S	261D	273S	281S	289S	291S	299S	307S	309S	318S
		320S	329S	331S	340S	342S											
105	264	253X	264D														
110	276	264X	276D														
115	283	276X	283D														
120	292	290X	292D														
125	294	283X	294D														
130	301	294X	301D														
135	310	308X	310D														
140	312	301X	312D														
145	321	319X	321D														
150	323	312X	323D														
155	332	330X	332D														
160	334	323X	334D														
165	343	341X	343D														
170	345	334X	345D														
175	352	345X	352D														
180	364	361V	364D														
185	382	379X	382D														
190	388	383X	388D														
195	389	376V	381X	382X	387X	389D											
200	391	372V	391D														
205	395	393V	395D														
210	400	368X	400D														
215	410	407X	410D														
220	416	411X	416D														
225	417	404V	409X	410X	415X	417D											
230	419	400V	419D														
235	423	421V	423D														
240	427	396X	427D														
245	429	428W	428W	429D													

Table C-1

STAR DICTIONARY (CONT'D)

250	437	435V	437D	
255	442	431X	442D	
260	445	443V	445D	
265	446	438X	446D	
270	448	428W	448D	
275	456	454V	456D	
280	461	450X	461D	
285	464	462V	464D	
290	465	457X	465D	
295	466	427V	447X	466D
300	471	470V	471D	
305	506	501X	506D	
310	522	486V	522D	
315	528	527W	527W	528D
320	543	537V	543D	
325	548	546V	548D	
330	553	532X	553D	
335	559	553V	559D	
340	564	562V	564D	
345	565	549X	565D	
350	567	527W	567D	
355	582	576V	582D	
360	587	585V	587D	
365	592	571X	592D	
370	598	592V	598D	
375	603	601V	603D	
380	604	588X	604D	
385	605	526V	566X	605D
390	617	616W	616W	617D
395	620	616W	620D	
400	622	615V	619X	622D
405	634	629V	634D	
410	636	635W	635W	636D
415	639	635W	639D	
420	641	624V	638X	641D
425	642	623V	642D	
430	656	655W	655W	656D
435	660	655W	660D	
440	663	654V	659X	663D
445	664	653V	664D	
450	673	672W	672W	673D
455	675	672W	675D	
460	678	671V	674X	678D
465	679	668V	679D	
470	685	684W	684W	685D
475	692	684W	692D	
480	695	691X	695D	
485	696	683V	696D	
490	702	701W	701W	702D
495	704	701W	704D	
500	705	700V	703X	705D
505	712	711W	711W	712D
510	715	711W	715D	
515	717	710V	714X	717D
520	718	709V	718D	
525	736	731V	736D	
530	741	725V	741D	
535	764	751V	764D	

Table C-1

STAR DICTIONARY (CONT'D)

540	786	774V	786D											
545	791	769V	791D											
550	797	745X	797D											
555	816	803V	816D											
560	838	826V	838D											
565	843	821V	843D											
570	849	722V	797X	849D										
575	858	857S	858D											
580	860	859S	860D											
585	880	879S	880D											
590	896	855X	896D											
595	903	902S	903D											
600	906	905S	906D											
605	908	907W	908D											
610	909	908S	909D											
615	911	907W	911D											
620	912	911S	912D											
625	914	907W	914D											
630	915	914S	915D											
635	917	910X	913X	917D										
640	919	918S	919D											
645	927	925S	927D											
650	942	941S	942D											
655	947	946S	947D											
660	949	948S	949D											
665	953	945S	952S	953D	966S	1337S	1343S	1349S						
670	955	954S	955D											
675	963	960X	963D											
680	964	961S	963S	964D										
685	965	959V	962X	965D										
695	969	968S	969D											
700	971	970S	971D	982S	990S	999S								
705	974	973V	974D											
710	976	974S	976D	984S	992S	1001S								
715	980	979S	980D											
720	984	983V	984D											
725	986	977V	986D											
730	987	967X	987D											
735	989	988S	989D											
740	992	991V	992D											
745	997	996S	997D											
750	1001	1000V	1001D											
755	1003	994V	1003D											
760	1004	987X	1004D											
765	1007	1006S	1007D											
770	1010	1009S	1010D											
775	1016	1014S	1016D											
780	1018	1013V	1018D											
785	1023	900S	944S	1005S	1022S	1023D	1200S							
790	1025	901S	1024S	1025D	1201S									
795	1027	1026S	1027D											
800	1031	1030S	1031D											
805	1036	1035S	1036D											
810	1040	1038S	1040D											
815	1042	1037X	1042D											
820	1043	1034V	1043D											
825	1049	1048W	1048W	1049D										
830	1050	1049S	1050D	1076S	1093S	1110S	1126S	1148S	1167S	1184S	1236S	1251S	1267S	1282S	1298S	1313S	1328S

Table C-1

STAR DICTIONARY (CONT'D)

		1356S
835	1052	1051S 1052D 1094S 1168S 1237S 1268S 1299S
840	1054	1053S 1054D 1079S
845	1056	1055S 1056D 1080S 1098S 1113S 1172S 1187S 1241S 1254S 1272S 1285S 1303S 1316S
850	1061	1060S 1061D 1081S 1099S 1114S 1173S 1188S 1242S 1255S 1273S 1286S 1304S 1317S
855	1067	1066S 1067D 1083S 1101S 1116S 1137S 1155S 1175S 1190S 1244S 1257S 1275S 1288S 1306S 1319S
860	1070	1069S 1070D 1085S
865	1072	1068X 1072D
870	1073	1065V 1073D
875	1074	1048W 1074D
880	1078	1077S 1078D 1111S 1185S 1252S 1283S 1314S
885	1086	1084X 1086D
890	1087	1082V 1087D
895	1088	1075X 1088D
900	1093	1092W 1092W 1093D
905	1096	1095S 1096D 1112S
910	1104	1103S 1104D 1118S
915	1106	1102X 1106D
920	1107	1100V 1107D
925	1108	1092W 1108D
930	1119	1117X 1119D
935	1120	1115V 1120D
940	1121	1109X 1121D
945	1128	1127S 1128D
950	1130	1129S 1130D 1151S
955	1143	1140V 1143D
960	1144	1139X 1144D
965	1145	1144S 1145D 1160S
970	1146	1136V 1138X 1146D
975	1148	1125X 1148D
980	1150	1149S 1150D
985	1159	1156V 1159D
990	1160	1155X 1160D
995	1161	1152V 1154X 1161D
1000	1162	1147X 1162D
1005	1167	1166W 1166W 1167D
1010	1170	1169S 1170D 1166S
1015	1178	1177S 1178D 1192S 1246S 1259S 1277S 1290S 1308S 1321S
1020	1180	1176X 1180D
1025	1181	1174V 1181D
1030	1182	1166W 1182D
1035	1193	1191X 1193D
1040	1194	1189V 1194D
1045	1195	1183X 1195D
1050	1203	1202S 1203D
1055	1207	1206S 1207D
1060	1212	1211S 1212D
1065	1216	1215S 1216D
1070	1221	1220S 1221D
1075	1227	1224S 1227D
1080	1230	1222X 1230D
1085	1231	1219V 1231D
1090	1236	1235W 1235W 1236D
1095	1239	1238S 1239D 1253S
1100	1247	1245X 1247D
1105	1248	1243V 1248D
1110	1249	1235W 1249D
1115	1260	1258X 1260D

Table C-1

STAR DICTIONARY (CONT'D)

1120	1261	1256V 1261D	
1125	1262	1250X 1262D	
1130	1267	1266W 1266W	1267D
1135	1270	1269S 1270D	1284S
1140	1278	1276X 1278D	
1145	1279	1274V 1279D	
1150	1280	1266W 1280D	
1155	1291	1289X 1291D	
1160	1292	1287V 1292D	
1165	1293	1281X 1293D	
1170	1298	1297W 1297W	1298D
1175	1301	1300S 1301D	1315S
1180	1309	1307X 1309D	
1185	1310	1305V 1310D	
1190	1311	1297W 1311D	
1195	1322	1320X 1322D	
1200	1323	1318V 1323D	
1205	1324	1312X 1324D	
1210	1330	1329S 1330D	
1215	1342	1339V 1342D	
1220	1344	1338X 1344D	
1225	1347	1344V 1347D	
1230	1348	1340S 1345S	1348D
1235	1351	1350S 1351D	
1245	1358	1357S 1358D	

Table C-1

STAR DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
STOP
INTERNAL SUBPROGRAM

DO	113	177	186	188	206	214	216	361	372	376	393	400	404	421	427	435	443	454	462	470	486
	526	537	546	553	562	576	585	592	601	615	623	624	629	653	654	668	671	683	700	709	710
	722	725	731	751	769	774	803	821	826	959	973	977	983	991	994	1000	1013	1034	1065	1082	1100
	1115	1136	1140	1152	1156	1174	1189	1219	1243	1256	1274	1287	1305	1318	1339	1344					
IF(L)	123	150	157	180	191	200	209	219	227	243	253	264	276	283	290	294	301	308	312	319	323
	330	334	341	345	368	374	375	377	378	379	382	383	384	385	396	402	403	405	406	407	410
	411	412	413	431	447	450	501	502	532	566	571	618	619	621	632	633	638	657	658	659	661
	662	674	676	677	691	703	714	734	735	739	740	745	757	760	782	797	809	812	834	855	960
	967	987	1037	1068	1075	1084	1102	1109	1117	1125	1138	1139	1147	1154	1155	1176	1183	1191	1222	1245	1250
	1258	1276	1281	1289	1307	1312	1320	1338	1353												
GOTO(UC)	123	150	157	180	191	200	209	219	227	243	253	264	276	283	290	294	301	308	312	319	323
	330	334	341	345	368	379	381	382	383	387	396	407	409	410	411	415	431	438	447	450	457
	501	532	549	566	571	588	619	638	659	674	691	703	714	745	797	855	910	913	960	962	967
	987	1037	1068	1075	1084	1102	1109	1117	1125	1138	1139	1147	1154	1155	1176	1183	1191	1222	1245	1250	1258
	1276	1281	1289	1307	1312	1320	1338	1353													
GOTO(C)	428	527	616	635	655	672	684	701	711	907	1048	1092	1166	1235	1266	1297					
CALL FCT REF	98	472	474	512	541	557	580	596	610	613	647	650	687	761	783	813	835	1359			
	688	693	746	798																	
INPUT	109	121	142	144	155	176	178	189	197	205	207	217	225	240	250	260	273	281	289	291	299
	307	309	318	320	329	331	340	342	351												
OUTPUT	857	859	879	900	901	902	905	908	911	914	918	925	941	944	945	946	948	952	954	961	963
	966	968	970	974	979	982	984	988	990	992	996	999	1001	1005	1006	1009	1014	1022	1024	1026	1030
	1035	1038	1049	1051	1053	1055	1060	1066	1069	1076	1077	1079	1080	1081	1083	1085	1093	1094	1095	1098	1099
	1101	1103	1110	1111	1112	1113	1114	1116	1118	1126	1127	1129	1137	1144	1148	1149	1151	1153	1160	1167	1168
	1169	1172	1173	1175	1177	1184	1185	1186	1187	1188	1190	1192	1200	1201	1202	1206	1211	1215	1220	1224	1236
	1237	1238	1241	1242	1244	1246	1251	1252	1253	1254	1255	1257	1259	1267	1268	1269	1272	1273	1275	1277	1282
	1283	1284	1285	1286	1288	1290	1298	1299	1300	1303	1304	1306	1308	1313	1314	1315	1316	1317	1319	1321	1328
	1329	1337	1340	1343	1345	1349	1350	1356	1357												

Table C-2

INIVOL DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

VARIABLE TABLE

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

ADOME	CM		DIMEN	12E	46A								
ARACYL FCTN				25B	34B								
AREAFR FCTN				22B									
ARSPHR FCTN				19B	28B	37B							
ASKIN	CM		DIMEN	12E	45A								
ATOT	CM		DIMEN	12E	44A	45B							
A1	CM		DIMEN	12E	19A	44B							
A2	CM		DIMEN	12E	22A	44B							
A3	CM		DIMEN	12E	25A	44B							
A4	CM		DIMEN	12E	28A	44B	45B	46B					
A6	CM		DIMEN	12E	34A	44B							
A7	CM		DIMEN	12E	37A	44B							
CYLNDR FCTN				24B	33B								
CYLSPH FCTN				31B									
DIMEN LBCM	CM			12E									
EQLR DMVR	CM		DIMEN	12E									
FRCONE FCTN				21B									
HDH2	CM		DIMEN	12E									
HDO2	CM		DIMEN	12E									
HSPHER FCTN				18B	27B	36B							
INIVOL SBRT				2A									
L1	RL			10E	21C	22C							
L2	RL			10E	21C	22C	24C	25C					
L3	RL			10E	24C	25C	33C	34C					
L4	RL			10E	33C	34C							
R1				18C	19C								
R2				18C	19C	21C	22C						
R3				27C	28C	31C	33C						
R4				21C	22C	24C	25C	27C	28C	31C	33C	34C	36C	37C
R5				36C	37C								
UVLH2	CM		DIMEN	12E									
UVLO2	CM		DIMEN	12E									
VTH2	CM		DIMEN	12E	41A	43B							
VTOT	CM		DIMEN	12E	43A								
VTO2	CM		DIMEN	12E	39A	43B							
V1	CM		DIMEN	12E	18A	39B							
V2	CM		DIMEN	12E	21A	39B							
V3	CM		DIMEN	12E	24A	39B							
V4	CM		DIMEN	12E	27A	39B							
V5	CM		DIMEN	12E	31A	41B							
V6	CM		DIMEN	12E	33A	41B							
V7	CM		DIMEN	12E	36A	41B							

Table C-2

INIVOL DICTIONARY

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

FCT REF	18	19	21	22	24	25	27	28	31	33	34	36	37	
RTRN(S)	47													
SUB PROG	2													

ULLHED DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
= UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE.
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

ADOME	CM	DIMEN	8E											
ASKIN	CM	DIMEN	8E											
ATOT	CM	DIMEN	8E											
A1	CM	DIMEN	8E											
A2	CM	DIMEN	8E											
A3	CM	DIMEN	8E											
A4	CM	DIMEN	8E											
A6	CM	DIMEN	8E											
A7	CM	DIMEN	8E											
CYMSPH SBRT			58B											
DIMEN LBCM CM			8E											
ELIPSC SBRT			27B	42B	50B									
EQLR DMVR CM		DIMEN	8E											
H			42C	43B	58C	59B								
HDH2	CM	DIMEN	8E	50C	54A	59A								
HDO2	CM	DIMEN	8E	27C	31A	38A	39A	39B	43A					
HL			35A	37B	38B	38B								
IOT			23H	46H										
L1	RL		6E	35B	43B									
L2	RL		6E	35B	39B									
L3	RL		6E	39B	43B	59B								
L4	RL		6E	59B										
PI			31B	37B	38B	38B	38B	54B						
R1			42C	43B										
R2			36B	42C										
R3			27C	31B	39B	43B	58C	59B						
R4			27C	31B	31B	36B	37B	37B	37B	38B	50C	54B	54B	58C
R42			36A	37B	38B	38B								
R5			50C	54B	59B									
ULLHED SBRT			2A											
UVLH2	CM	DIMEN	8E	45A	46B									
UVLO2	CM	DIMEN	8E	22A	23B	42C								
VD			37A	38B										
VHP			57A	58C										
VLH2	FA		2A	45B	49B	50C	52B	54B	57B					
VLO2	FA		2A	22B	26B	27C	30B	31B	34B	37B				
VTH2	CM	DIMEN	8E	45B										
VTOT	CM	DIMEN	8E											
VTO2	CM	DIMEN	8E	22B										
V1	CM	DIMEN	8E											
V2	CM	DIMEN	8E	34B										
V3	CM	DIMEN	8E	30B	34B	37B								
V4	CM	DIMEN	8E	26B	30B	31B	34B	37B						
V5	CM	DIMEN	8E											
V6	CM	DIMEN	8E	52B	57B									

Table C-3

ULLHED DICTIONARY (CONT'D)

V7	CM	DIMEN	BE	49B	52B	54B	57B

Table C-3

ULLHED DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	18	18D	23S	46S	
15	27	26Y	27D		
20	30	26Y	26Y	30D	
25	31	30Y	30Y	31D	
30	34	30Y	34D		
35	35	34Y	34Y	35D	
40	42	34Y	42D		
45	45	28X	32X	40X	45D
50	50	49Y	50D		
55	52	49Y	49Y	52D	
60	54	52Y	52Y	54D	
65	57	52Y	57D		
70	60	51X	55X	60D	

Table C-3

ULLHED DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	

IF(L)	23	46			
IF(A)	26	30	34	49	52
GOTO(UC)	28	32	40	51	55
CALL	27	42	50	58	
RTRN(S)	61				
OUTPUT	23	46			
SUB PROG	2				

Table C-4

FLORES DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
- DMVR = DIMENSIONED VARIABLE
- FCTN = FUNCTION NAME
- LBCM = NAME OF LABELED COMMON
- SBRT = SUBROUTINE NAME
- SWVR = SWITCH VARIABLE
- NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
- AB = ABNORMAL
- CM = COMMON
- CP = COMPLEX
- DA = DATA
- DM = DIMENSION
- DP = DBL PRECISN
- EQ = EQUIVALENCE
- EX = EXTERNAL
- FA = FORML AGUMT
- IN = INTEGER
- LG = LOGICAL
- PR = PARAMETER
- RL = REAL
- NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
- A = SET EQUAL,DEFINED,ASSIGNED
- B = REFERENCED,CALLED
- C = CALLING SEQUENCE
- D = SUBSCRIPT
- E = SPECIFICATION
- J = DO PARAMETER
- H = I-O UNIT
- I = READ
- O = WRITE
- L = LIST

ABS	FCTN	20B														
ARG		56A	57C	68A	69C											
ATAN	FCTN	57B	69B													
BLOD		40A	41B	45B												
C		6A	17B	57B	69B											
CK		59A	62A	64A	65B											
D	FA	1A	7B	55A	55B	68B	97B	100B	103B	109B	112B	115B				
DIF		44A	46B													
DIFL		45A	46B													
FLORES	SBRT	1A														
ID	FA	1A	8B													
P		7A	19B	33B	34B	38B	39B	40B	50B	51B	56B					
PI		5A	32B	37B	49B											
RES	FA	1A	11A	14A	21A	24A	27A	29A	33A	34A	34B	42A	46A	54A	65A	
		65B	71A	74A	76A	81A	89A	94A	97A	100A	103A	106A	109A	112A	115A	
RESLD0		38A	44B	46B	50A											
RESLD8		39A	42B	44B	51A											
RES90		19A	21B	24B	27B	29B										
SL		32A	34B	37A	40B	49A										
S1	FA	1A	17B	32B	37B	49B	56B	60B	84A	84B						
S2	FA	1A	17B	19B	32B	33B	37B	39B	39B	49B	50B	51B	54B	56B	66B	
		76B														
TEST		18A	20C	23B												
THETA		17A	18B	24B	26B	27B	29B	57A	58B	59B	61B	62B	69A	70B	73B	

Table C-4

FLORES DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	11	8W	11D		
15	14	8W	14D		
20	17	8W	17D		
25	23	20X	23D		
30	26	23X	26D		
33	29	26X	29D		
40	32	8W	32D		
45	37	8W	37D		
50	40	40D	52X		
55	44	41X	44D		
60	49	8W	49D		
65	54	8W	54D	85X	
70	61	58X	61D		
75	64	61X	64D		
80	65	60X	63X	65D	
85	68	8W	68D		
90	73	70X	73D		
95	76	73X	76D		
100	79	8W	79D		
105	80	79S	80D		
110	84	8W	84D		
115	87	8W	87D		
120	88	87S	88D		
125	92	8W	92D		
130	93	92S	93D		
135	97	8W	8W	97D	
140	100	8W	100D		
145	103	8W	8W	8W	103D
150	106	8W	106D		
155	109	8W	8W	109D	
160	112	8W	112D		
165	115	8W	115D		

Table C-4

FLORES DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

IF(L)	20	23	26	41	58	61	70	73														
GOTO(UC)	20	23	26	41	52	58	60	61	63	70	73	85										
GOTO(C)	8																					
FCT REF	20	57	69																			
RTRN(S)	12	15	22	25	28	30	35	43	47	66	72	75	77	82	90	95	98	101	104	107	110	
	113	116																				
OUTPUT	79	87	92																			
SUB PROG	1																					

Table C-5

PVAPOR DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

V A R I A B L E T A B L E

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML ASUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

EXP FCTN		3B	7B	8B	10B	10B	11B	11B	13B	17B	19B	21B	23B			
I	FA	1A	2B													
P	FA	1A	3A	5A	7A	8B	8A	10A	11B	11A	13A	15A	17A	19A	21A	
		23A	26A	29A												
PLOGMM		25A	26B	28A	29B											
PVAPOR SBRT		1A														
T	FA	1A	3C	5B	5B	7C	8C	10C	10C	11C	11C	13C	15B	17C	19C	
		21C	23C	25B	28B											

Table C-5

PVAPOR DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	3	2W	3D	
15	5	2W	2W	5D
20	7	2W	2W	7D
25	10	2W	10D	
30	13	2W	2W	13D
35	15	2W	2W	15D
40	17	2W	17D	
45	19	2W	19D	
50	21	2W	21D	
55	23	2W	23D	
60	25	2W	25D	
65	28	2W	28D	

Table C-5

PVAPOR DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

IF(L)	8	11										
GOTO(C)	2											
FCT REF	3	7	8	10	10	11	11	13	17	19	21	23
RTRN(S)	4	6	9	12	14	16	18	20	22	24	27	30
SUB PROG	1											

Table C-6

ZFIND DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
= UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

A	DMVR DM DA DA DA **	3E	16A	18A	20A	22A	24A	26A	28A	30A	32A	34A	36A	38A	40A	
		42A	44A	46A	102B	102B	102B	102B	102B	102B						
ABS	FCTN	54B	66B													
AS		59A	65B	68B												
BS		60A	65B	65B	68B	68B	68B	68B	68B							
DELTA		78A	80B													
E		63A	66B	72A	72B											
FACTOR		79A	80B	81A	81B											
G	DMVR DM DA DA DA	2E	7A	9A	11A	57B	59B	59B	59B	59B	60B	60B	60B	65B	68B	
I		7D	7L	9D	9L	11D	11L									
IN		61A	70A	70B	74B											
J		16D	16L	18D	18L	20D	20L	22D	22L	24D	24L	26D	26L	28D	28L	
		30D	30L	32D	32L	34D	34L	36D	36L	38D	38L	40D	40L	42D	42L	
		44D	44L	46D	46L											
K		4D	4L													
N	FA	1A	48B	50D	50D	52C	57D	58B	58B	59D	59D	59D	59D	60D	60D	
		60D	65D	68D	88D	102D	102D	102D	102D	102D	102D					
N2		62A	71A	71B	72B	73B	73A									
OLDV		77A	80B													
P	FA	1A	53B	57B	65B	88O	95C									
PTDENS	FCTN	95B														
PVAPOR	SBRT	52B														
S	DMVR DM DA	2E	13A	88O												
T	FA	1A	49B	49B	50B	50B	52C	57B	65B	65B	68B	68B	88O	94B	102B	
		102B	102B	102B	102B	102B	102B	102B								
TRY		53A	54C													
TRYP		52C	53B													
TS	DMVR DM DA	3E	4A	50B	50B											
TT		94A	95C													
V	FA	1A	64A	65B	65B	65B	68B	63B	68B	68B	68B	68B	68B	72A	75B	
		76B	77B	80A	82B	88O	92A	95A	96A	96B	97A	97B	99A	102A		
VF		57A	64B	83O	92B	97B										
Y		65A	66C	75B	77B	78B										
YP		68A	75B	77B	78B											
ZFIND	SBRT	1A														

Table C-6

ZFIND DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	55	48X	50X	55D
15	65	65D	84X	
20	80	80D	82X	
25	83	76X	83D	
30	85	66X	85D	
35	87	74X	87D	
40	89	88S	89D	
45	94	58X	94D	
50	97	86X	93X	97D
55	99	49X	99D	
60	101	54X	101D	

Table C-6

ZFIND DICTIONARY (CONT'D)

```
                                        T R A N S F E R   T A B L E
     ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT,  THE COMPLETE LIST FOLLOWS
     DO                 GOTO (UNCONDITIONAL)    CALL                    RETURN (NON-STANDARD)   INPUT        STOP
     IF (LOGICAL)       GOTO (ARITHMETIC)       FUNCTION REFERENCE      ASSIGN                  OUTPUT
     IF (ARITHMETIC)    GOTO (CONDITIONAL)      RETURN (STANDARD)       TAPES                   INTERNAL SUBPROGRAM

   IF(L)                48   49   50   54   58   66   72   73   74   76   82
   GOTO(UC)             48   49   50   54   58   66   74   76   82   84   86   93
   CALL                 52
   FCT REF              54   66   95
   RTRN(S)              98  100  103
   OUTPUT               88
   SUB PROG              1


 @ASG,A XREF*XREF.
 FAC WARNING     040000000200
```

Table C-7

FINDR DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY	THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE	
= UNDIMENSIONED VARIABLE	AB = ABNORMAL	EX = EXTERNAL	A = SET EQUAL, DEFINED, ASSIGNED	
DMVR = DIMENSIONED VARIABLE	CM = COMMON	FA = FORML AGUMT	B = REFERENCED, CALLED	
FCTN = FUNCTION NAME	CP = COMPLEX	IN = INTEGER	C = CALLING SEQUENCE	H = I=O UNIT
LBCM = NAME OF LABELED COMMON	DA = DATA	LG = LOGICAL	D = SUBSCRIPT	I = READ
SBRT = SUBROUTINE NAME	DM = DIMENSION	PR = PARAMETER	E = SPECIFICATION	O = WRITE
SWVR = SWITCH VARIABLE	DP = DBL PRECISN	RL = REAL	J = DO PARAMETER	L = LIST
NMLT = NAMELIST NAME	EQ = EQUIVALENCE	NL = NAMELIST		

FINDR	FCTN		1A	5A	
G	DMVR	DM DA	2E	3A	5B
N		FA	1A	5D	

Table C-7

FINDR DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	

RTRN(S)	6
SUB PROG	1

Table C-8

PTDENS DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

V A R I A B L E T A B L E

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

A = SET EQUAL, DEFINED, ASSIGNED
B = REFERENCED, CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

AA	DMVR DM EQ DA	4E 6E 29A
AB	DMVR DM EQ DA	4E 6E 39A
AC	DMVR DM EQ DA	4E 6E 49A
AD	DMVR DM EQ DA	4E 6E 59A
AE	DMVR DM EQ DA	4E 6E 69A
AF	DMVR DM EQ DA	4E 6E 79A
AG	DMVR DM EQ DA	4E 6E 89A
AH	DMVR DM EQ DA	4E 6E 99A
AI	DMVR DM EQ DA	4E 6E 109A
BP	DMVR DM DA	2E 17A 212B
BT	DMVR DM DA	2E 23A 218B
DP	DMVR DM DA	2E 20A 212B
DT	DMVR DM DA	2E 26A 218B
F		216A 217B 225B 225B
FF		221A 222B 225B 225B
FI		215A 216B 220A 221B
FP		212A 213B 216B 217A 225B 225B
FT		218A 219B 221B 222A 225B 225B
I		158J 159D 161A 162D 162D 162D 162D 162D 162D 223A 224B 225D 225D
IP		213A 214B 214A 215B 223B
IT		219A 220B 223B
J		224A 225D 225D
JP	DMVR DM DA	2E 15A 223B 224B
LOC	DMVR DM DA	2E 13A 223B
MX	DMVR DM DA	2E 16A 214B 214B
N		121A 123A 126A 128A 132A 134A 138A 141A 148A 151A 153A 156A 167A 169A 172A 177A 180A 182A 185A 188A 190A 193A 196A 200A 202A 206A 208A 210A 211B 212D 212D 214D 214D 218D 223D 224D
N1		139A 142A 211A 218D 223D
P		114A 115B 115A 120B 125B 131B 137B 144B 146B 147B 150B 157B 159B 162B 166B 171B 176B 179B 184B 187B 192B 195B 198B 199B 205B 212B
PRES	FA	1A 114B
PS	DMVR DM DA	2E 9A 159B 162B 162B 162B
PTDENS	FCTN	1A 225A
R	DMVR DM EQ EQ EQ **	2E 6E 6E 6E 6E 6E 6E 6E 6E 6E 225B 225B 225B 225B
T		116A 117B 118B 119B 130B 136B 139A 145B 145A 155B 163B 165B 174B 175B 204B 211B 218B
TEMP	FA	1A 116B
TM		162A 163B
TS	DMVR DM DA	2E 11A 162B 162B 162B
TZ		144A 145B 145B

Table C-8

PTDENS DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	123	120X	123D														
15	125	119X	125D														
20	128	125X	128D														
25	130	118X	130D														
30	134	131X	134D														
35	136	130X	136D														
40	141	137X	141D														
45	144	117X	144D														
50	150	147X	150D														
55	153	150X	153D														
60	155	146X	155D														
65	160	158V	159Y	160D													
70	162	159Y	159Y	162D													
75	165	155X	165D														
80	169	166X	169D														
85	171	165X	171D														
90	174	171X	174D														
95	179	176X	179D														
100	182	179X	182D														
105	184	175X	184D														
110	187	184X	187D														
115	190	187X	190D														
120	192	174X	192D														
125	195	163X	192X	195D													
130	198	195X	198D														
135	202	199X	202D														
140	204	198X	204D														
145	208	205X	208D														
150	210	204X	210D														
155	211	122X	124X	127X	129X	133X	135X	140X	143X	149X	152X	154X	157X	164X	168X	170X	173X
		178X	181X	183X	186X	189X	191X	194X	197X	201X	203X	207X	209X	211D			

Table C-8

PTDENS DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

DO	158																				
IF(L)	115	117	118	119	120	125	130	131	136	137	145	146	147	150	155	157	163	165	166	171	174
	175	176	179	184	187	192	195	198	199	204	205	211	214								
IF(A)	159																				
GOTO(UC)	117	118	119	120	122	124	125	127	129	130	131	133	135	137	140	143	146	147	149	150	152
	154	155	157	163	164	165	166	168	170	171	173	174	175	176	178	179	181	183	184	186	187
	189	191	192	194	195	197	198	199	201	203	204	205	207	209							
RTRN(S)	226																				
SUB PROG	1																				

Table C-9

WTCTRL DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
= UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

A			62A	66A	68B											
B			63A	67A	68B											
CBWT	FCTN		47B													
CFTW	FCTN		39B													
D		FA	1A	24B	29B	32B	39C	47C	68B							
ETU	DMVR	DM DA DA	4E	5A	6A	23B										
I		FA	1A	13B	34O											
IB			46A	47C	50A	53A	56A	59A								
IDV			38A	39C	41A	43A										
IF		FA	1A	23D												
II		FA	1A	32D												
IM		FA	1A	19B	20B	21B	23D	28D	29D	29D						
IV		FA	1A	38B												
J			5D	5L	6O	6L	7D	7L	8D	8L	9D	9L	25A	26A	27A	28D
			28D													
MINTHK	DMVR	RL DM DA	2E	3E	9A	28B	28B									
P		FA	1A	24B	26B	27B	39C	47C								
RHOI	DMVR	DM DA	3E	8A	32B											
RHOL	DMVR	DM DA	5E	7A	29B											
ST			23A	24B												
S1		FA	1A	30B	32B	68B										
S2		FA	1A													
S3		FA	1A	32B												
THKL			24A	28B	28A	29B										
WGTFT			29A	30B												
WI		FA	1A	11A	32A											
WT		FA	1A	12A	16A	30A	36A	39A	47A	68A						
WTCTRL	SBRT		1A													

Table C-9

WTCTRL DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	16	13W	16D							
15	19	13W	13W	13W	13W	13W	13W	13W	13W	19D
20	22	19X	22D							
25	34	13W	13W	13W	34D					
30	35	34S	35D							
35	38	13W	13W	38D						
40	39	39D	42X	44X						
45	41	13W	41D							
50	43	13W	43D							
55	46	13W	46D							
60	47	47D	51X	54X	57X	60X				
65	50	13W	50D							
70	53	13W	13W	13W	53D					
75	56	13W	56D							
80	59	13W	59D							
85	62	20X	62D							
90	66	21X	66D							
95	68	64X	68D							

Table C-9

WTCTRL DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	

IF(L)	19	20	21	26	27	28				
GOTO(UC)	19	20	21	42	44	51	54	57	60	64
GOTO(C)	13									
FCT REF	39	47								
RTRN(S)	17	33	37	40	48	69				
OUTPUT	34									
SUB PROG	1									

Table C-10

CFTW DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
- DMVR = DIMENSIONED VARIABLE
- FCTN = FUNCTION NAME
- LBCM = NAME OF LABELED COMMON
- SBRT = SUBROUTINE NAME
- SWVR = SWITCH VARIABLE
- NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
- AB = ABNORMAL
- CM = COMMON
- CP = COMPLEX
- DA = DATA
- DM = DIMENSION
- DP = DBL PRECISN
- EQ = EQUIVALENCE
- EX = EXTERNAL
- FA = FORML AGUMT
- IN = INTEGER
- LG = LOGICAL
- PR = PARAMETER
- RL = REAL
- NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
- A = SET EQUAL,DEFINED,ASSIGNED
- B = REFERENCED,CALLED
- C = CALLING SEQUENCE
- D = SUBSCRIPT
- E = SPECIFICATION
- J = DO PARAMETER
- H = I-O UNIT
- I = READ
- O = WRITE
- L = LIST

CFTW	FCTN		1A	21A	23A	26A	28A							
C1	DMVR	DM DA	5E	11A	21B									
C2	DMVR	DM DA	5E	12A	23B									
C3	DMVR	DM DA	5E	13A	26B									
C4	DMVR	DM DA	5E	14A	28B									
D		FA	1A	18B	19B	20B	21B	21B	21B	23B	23B	23B	26B	28B
IDV		FA	1A	17B	17A	21D	21D	23D	23D	26D	26D	28D	28D	
K1	DMVR	RL DM DA	3E	5E	7A	21B								
K2	DMVR	RL DM DA	3E	5E	8A	23B								
K3	DMVR	RL DM DA	3E	5E	9A	26B								
K4	DMVR	RL DM DA	3E	5E	10A	28B								
P		FA	1A	19B	20B	25B								

Table C-10

CFTW DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	23	19X	20X	23D
15	25	18X	25D	
20	28	25X	28D	

Table C-10

CFTW DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT. THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

IF(L)	17	18	19	20	25
GOTO(UC)	18	19	20	25	
RTRN(S)	22	24	27	29	
SUB PROG	1				

Table C-11

CBWT DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL, DEFINED, ASSIGNED
B = REFERENCED, CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

CBWT	FCTN		1A	7A	10A	10B	12A	12B	12B
C1	DMVR	DM DA	3E	4A	7B	10B	12B		
C2	DMVR	DM DA	3E	5A	10B	12B			
D		FA	1A	7B					
I8		FA	1A	7D	7D	10D	10D	12D	12D
M	DMVR	RL DM DA	2E	3E	6A	7B			
P		FA	1A	8B	9B	12B			

Table C-11

CBWT DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED
S = FORMAT NUMBER
T = NONSTNDRD RTN
U = ASSIGNED
V = DO
W = GOTO (CNDTNL)
X = GOTO (UNCNDTNL)
Y = IF (ARITHMETIC)

10 12 9X 12D

Table C-11

CBWT DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL	SUBPROGRAM

IF(L)	8	9	
GOTO(UC)	9		
RTRN(S)	8	11	13
SUB PROG	1		

Table C-12

GOMTRY DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
- = UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

ALOG	FCTN					57B												
ARACYL	FCTN					36A												
AREAFR	FCTN					41A												
ARSPHR	FCTN					47A												
ASIN	FCTN					52B												
CONE	FCTN					2A	9A	13A	18A	22A	27A	32A	37A	42A	52A	57A	60A	
CYLNDR	FCTN					12A												
CYLSPH	FCTN					17A												
E						51A	52C	52B	56A	57B	57C	57C						
FRCONE	FCTN					21A												
H		FA	FA	FA	FA	2A	9B	12A	13B	21A	22B	36A	37B	41A	42C	42C		
HSPHER	FCTN					26A												
P1						9B	13B	18B	22B	37B	42B	52B	57B	60B				
P1203						27B	32B											
R		FA	FA	FA	FA	2A	9B	9B	12A	13B	13B	17A	18B	18B	21A	22B	22B	22B	26A
						27B	27B	31A	32B	32B	36A	37B	41A	42B	42C	47A	48B	51C	51C
						52B	52B	54B	56C	56C	56B	57B	57B	60B	60B				
RROT		FA	FA	FA	FA	17A	18B	26A	27B	31A	32B	47A	48B	51C	51C	51B	52B	54B	56C
						56C	57B	57B											
R2		FA	FA			21A	22B	22B	22B	41A	42B	42C							
SPHERE	FCTN					31A													
SQRT	FCTN					42B	51B	56B											

Table C-12

GOMTRY DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	54	48X	54D
15	60	54X	60D

Table C-12

GOMTRY DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

IF(L)	48	54									
GOTO(UC)	48	54									
FCT REF	42	51	52	56	57						
RTRN(S)	10	14	19	23	28	33	38	43	53	58	61
SUB PROG	2	12	17	21	26	31	36	41	47		

Table C-13

SPHSEG DICTIONARY

V A R I A B L E T A B L E

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
= UNDIMENSIONED VARIABLE
DMVR = DIMENSIONED VARIABLE
FCTN = FUNCTION NAME
LBCM = NAME OF LABELED COMMON
SBRT = SUBROUTINE NAME
SWVR = SWITCH VARIABLE
NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
AB = ABNORMAL
CM = COMMON
CP = COMPLEX
DA = DATA
DM = DIMENSION
DP = DBL PRECISN
EQ = EQUIVALENCE
EX = EXTERNAL
FA = FORML AGUMT
IN = INTEGER
LG = LOGICAL
PR = PARAMETER
RL = REAL
NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
A = SET EQUAL,DEFINED,ASSIGNED
B = REFERENCED,CALLED
C = CALLING SEQUENCE
D = SUBSCRIPT
E = SPECIFICATION
J = DO PARAMETER
H = I-O UNIT
I = READ
O = WRITE
L = LIST

ACOS	FCTN		24B										
COS	FCTN		27B										
CYMSPH	SBRT		39A										
D			43A	44B									
ELIPSG	SBRT		15A										
H		FA FA FA	2A	15A	35A	39A	44A						
I			25J	26B	27D	29J	30B	31D	31D				
K			30A	35D									
PHI3			24A	27C									
PI			43B										
PI203			11B	17B	27C								
PVOL		FA FA FA	2A	15A	19B	39A	43B						
RAD		FA FA FA	2A	11B	15A	17B	27B	31B	39A	43B	43B	44B	44B
RPD		FA FA	15A	17B	17B	39A	43B	43B					
SPHSEG	SBRT		2A										
TVOL			11A	17A	19B								
XI			26A	27C									
XM			19A	20B	21Q	24C							
Y	DMVR	DM	8E	27A	31B	31B	33Q	35B					

Table C-13

SPHSEG DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	18	12X	18D
15	23	20X	23D
20	28	25V	28D
25	32	29V	32D
30	35	31X	35D
35	47	33S	47D
40	48	21S	48D

Table C-13

SPHSEG DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO
IF (LOGICAL)
IF (ARITHMETIC)
GOTO (UNCONDITIONAL)
GOTO (ARITHMETIC)
GOTO (CONDITIONAL)
CALL
FUNCTION REFERENCE
RETURN (STANDARD)
RETURN (NON-STANDARD)
ASSIGN
TAPES
INPUT
OUTPUT
INTERNAL SUBPROGRAM
STOP

DO	25	29		
IF(L)	20	31		
GOTO(UC)	12	20	31	
FCT REF	24	27		
RTRN(S)	22	34	36	45
OUTPUT	21	33		
SUB PROG	2	15	39	

APPENDIX D
SOPSA CROSS REFERENCE

This Appendix contains a cross reference listing of all entry points in the SOPSA program. The names of the relocatable elements are listed alphabetically. Beside each element name, the names of the element entry points are listed. Beside each entry point name, the names of all relocatable elements in the SOPSA program which reference this entry point are listed.

Table D-1

SOPSA CROSS REFERENCE LISTING

ARACYL	01	(000635)	(GOMTRY) ,INIVOL
AREAFR	01	(000703)	(GOMTRY) ,INIVOL
ARSPHR	01	(000757)	(GOMTRY) ,INIVOL
CBWT	01	(000057)	(CBWT) ,WTCTRL
CFTW	01	(000125)	(CFTW) ,WTCTRL
CONE	01	(000244)	(GOMTRY)
CYLNDR	01	(000312)	(GOMTRY) ,INIVOL
CYLSPH	01	(000360)	(GOMTRY) ,INIVOL
CYMSPH	01	(000254)	(SPHSEG) ,ULLHED
ELIPSG	01	(000224)	(SPHSEG) ,ULLHED
FINDR	01	(000012)	(FINDR) ,STAR
FLORES	01	(000576)	(FLORES) ,STAR
FRCONE	01	(000433)	(GOMTRY) ,INIVOL
HSPHER	01	(000507)	(GOMTRY) ,INIVOL
INIVOL	01	(000162)	(INIVOL) ,STAR
PTDENS	01	(000564)	(PTDENS) ,STAR,ZFIND
PVAPOR	01	(000316)	(PVAPOR) ,ZFIND,STAR
SPHERE	01	(000562)	(GOMTRY)
SPHSEG	01	(000176)	(SPHSEG)
ULLHED	01	(000240)	(ULLHED) ,STAR
WTCTRL	01	(000265)	(WTCTRL) ,STAR
ZFIND	01	(000403)	(ZFIND) ,STAR